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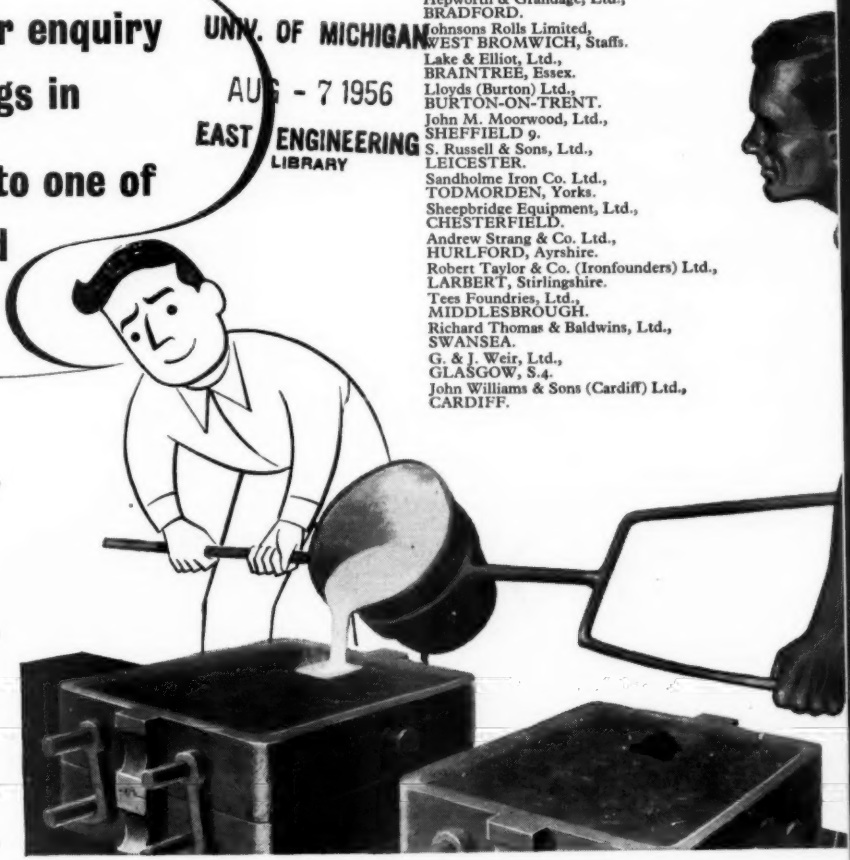

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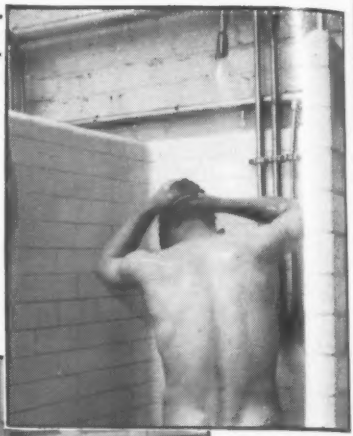

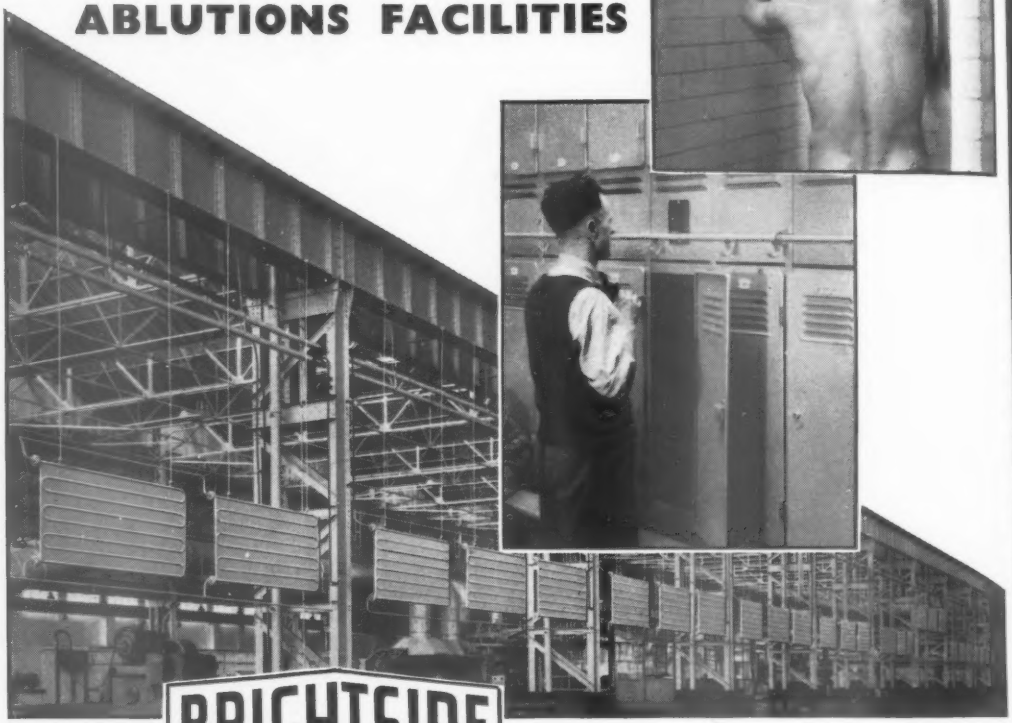

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Dip. Tech.—Foundry

Gradually the fog of misconception which surrounded the publication of the White Paper on technological training is being dispersed. The Government is making available a large sum of money to be spent on building (or extension) and equipment of technological colleges. Naturally, the money is to be spent over a period. There is more than one objective in their endeavours, but of major interest is the creation of a new diploma to be known as Dip. Tech. or Dip. Tech. (Eng.). Here, straightaway, there is disagreement amongst the educationists, as some maintain that it will be of higher standard than that required by the great technical institutes operating their own examinations. Others seem to think that it will not attain this level. However, it is supposed to be equivalent to a degree with honours.

Superficially, it would seem that only the very large concerns could profitably utilize the services of such men, but as the course of training is based on "sandwich" courses, the recipients of the diploma will have had much practical training, be they either works, or college based. It is the latter type which is of major interest to the bulk of the founders, as by closely associating themselves with an approved technical college, they could take a scholarship student and during the four-year or 10-term period give him a systematic training in foundry practice. So far as we understand the proposed curricula, the training to be given for the first three years will be devoted to basic sciences, leaving the fourth for the study of advanced technology in a definite field.

The question we are often being asked is whether this or that well-established technical college will provide courses leading to a Dip. Tech., covering foundry technology. This depends entirely on demand, and demand is not created just by chance—it has to be organized! Thus the solution is for district groups of foundry concerns to approach the technical college serving their area with a scheme guaranteeing some continuity of recruitment over a period of years. This need not be too onerous—so far as we have learned—because it will only be in the last few terms that specialized tuition will be given, the earlier period being spent in studying with other types of students, the sciences underlying engineering and metallurgy. The kudos to be attached to the diploma will not be properly established until a decade or so has passed. The recipients may become highly esteemed in the fields of plastics, or rubber technology, but for foundry practice, the industry may still prefer those trained at the National Foundry College. There are many vested interests in educational circles, but we should like to see this last-named establishment used as a finishing school for fourth-year students, but this so far as we know has not been envisaged. However—it is an idea!

Sheffield & District Foundry Exhibition

The Sheffield and District Foundry Exhibition, organized by the National Trades Technical Societies and the Sheffield and district branch of the Institute of British Foundrymen, is to be held at the Drill Hall, Edmund Road, Sheffield, from November 14 to 17. The objects of the exhibition include the stressing of the importance of the foundry industry by showing something of its history and achievements; to show a selection of high-grade castings made locally; to present recent foundry developments in the fields of education, research, techniques, literature and testing; to demonstrate the progress made in the training of youths, their opportunities for technical study leading to professional status and the advantages the foundry offers as a career; and the showing of the latest foundry equipment and materials. At the exhibition, the prizes gained at a recently held apprentice competition will be presented. Tests were held in both patternmaking and moulding. The competition extended to a radius of 18 miles from Sheffield and no fewer than 120 candidates competed. The winning entries will be on exhibit and all candidates will receive a certificate showing that they have submitted themselves for examination.

Further information can be obtained on applying to Mr. W. H. Bolton, 234, Brookhill, Sheffield, 3.

OEEC Meeting in Paris

Ministers of the 17 member countries of the Organization for European Economic Co-operation are meeting in Paris this week, to discuss the achievements of the organization and the trade and economic problems which still have to be solved. Appropriately, OEEC has just published a new edition of the booklet, *OEEC at Work in Europe*, which gives an account of the organization's activities in the form of short studies by members of the secretariat dealing with their particular spheres of work. In the opening article, Mr. René Sergent, secretary general of the OEEC, says that the organization has radically transformed the life of the 17 western European member states. Any economic problems which seem likely to be solved more easily by combined action are studied jointly: and confidential information is exchanged. "When it is remembered how cautious the European governments were before the war in supplying one another with the economic information at their disposal, the full extent of the progress that has been made can be appreciated," Mr. Sergent adds. "This permanent co-operation within the organization is all the more fruitful in that the United States and Canada are closely associated with its work when problems of interest to both western Europe and North America are studied."

Latest Foundry Statistics

The Council of Ironfoundry Associations announces the following number of ironfoundry workers were employed in the United Kingdom during the week ending June 2, 1956: Males, 134,461; females, 10,305; making a total of 144,766. This shows a reduction in the total of 280 over a month ago, but 264 increase over the returns for May 1955.

Fuel Economy in UK Steelworks

Particular reference to waste-heat recovery in British iron and steel works is made in the annual report of the National Industrial Fuel Efficiency Service. Revealing that 14 steelworks in the UK cut fuel costs by 27 per cent. last year, the report declares that this was the highest saving in any British industry. According to Dr. Angus MacFarlane, chief executive of NIFES, the big savings in the iron and steel trades were mainly achieved by piping heat from one operation where excess was generated to another. Although he admits that the 27 per cent. saving could not be repeated throughout the industry, Dr. MacFarlane believes that there is great scope for improvement.

Introducing the report at a Press conference in London, Dr. MacFarlane said that British factories spent between £30,000,000 and £35,000,000 a year in heating useless air. If excess air consumption in boiler plants were cut out it could save the country the "staggering" figure of 10,000,000 tons of coal each year.

The report shows that the capital cost of equipment needed to save a ton of coal is £13 16s., compared with a capital cost of about £50 needed to extract an extra ton from the ground. During the past year, it is added, 495 surveys were carried out in various works by NIFES, resulting in an average fuel saving of 15.1 per cent.

Capital Expenditure in 1957

Some 600 companies are to be asked by the Board of Trade to provide a forecast of their expected capital expenditure during 1957. The firms, which include all the largest companies and a representative number of smaller ones, regularly contribute to the Board's quarterly inquiry into capital expenditure and have already supplied information on their expected capital expenditure in recent quarters.

This request follows a meeting in March between the Prime Minister and the Federation of British Industries, at which it was agreed that it was important for the Government to be supplied with up-to-date information of the trends in industry's investment plans. After further discussion between the Board of Trade and the Federation of British Industries, it was agreed that there was particular need for the Government to have as early an indication as possible of industry's capital expenditure plans for 1957, and in making this request to companies the Board of Trade has the full support of the federation.

Leyland's Acquire Another Factory

The Government tank factory situated at Farington, near Preston, has been purchased by Leyland Motors, Limited. Its production capacity will be used to assist the firm in their current expansion programmes. The factory is situated adjacent to the main Leyland factories in Lancashire and was originally built and managed by the company for the Ministry of Supply. It occupies a site of 104 acres and is believed to be the largest and most modern of its kind in Western Europe. The buildings cover more than 1,000,000 sq. ft. and include up-to-date tool-rooms and development departments, heat-treatment and plate sections, large and well-equipped machine shops, together with spacious assembly bays, ancillary equipment and a power-station. The labour force, including key personnel, will be re-absorbed by the company, who are anxious to avoid any redundancy.

Shrinkage Defects in Grey-iron Castings*

By I. C. H. Hughes, M.Sc., A.I.M. and J. H. Gittus, B.Sc.

The effects of pouring temperature, metal composition, mode of solidification, and casting design upon shrinkage defects in grey-iron castings are commented upon. Hypotheses based on a study of the mode of solidification are proposed to account for the shrinkage characteristics of phosphoric and nodular irons.

Although a substantial amount of work has been performed and published on the subject, there are still important deficiencies in the knowledge of the causes of shrinkage defects in iron castings. This tends to reduce the extent to which research on shrinkage has benefited the ironfounding industry, and one purpose of the present Paper is to provide a coherent account of what is known and of matters which merit further investigation. To achieve this, the Authors have drawn freely on the work of previous investigators as well as on their own.

Causes

The size and dispersion of shrinkage defects are determined by three major factors:—(*a*) *The magnitude of the change in the volume of the casting which occurs prior to, and during, solidification.* Liquid metal contracts as it cools, and also (usually) as it solidifies. Both processes can cause cavities to form in a casting. (*b*) *The way in which change in volume acts.* Solidification-contraction need not necessarily cause cavities. Under certain circumstances, it can simply bring about a general reduction in the size of a casting, which does not constitute a defect. (*c*) *The distribution of solid and liquid metal in the solidifying casting.* A casting made in an alloy which solidifies over a range of temperatures will tend to freeze simultaneously in all regions during practically the entire period of solidification. Solidification-contraction will also, therefore, occur simultaneously in all parts of the casting, and the resultant cavities will take the form of dispersed porosity.

Variables which influence the formation of shrinkage defects in grey iron through their effects on these three factors may be summarized as follows:—(1) Pouring temperature; (2) composition; (3) mechanism of solidification; (4) design of casting; and (5) gas. Pouring temperature and composition influence the change in volume of the liquid metal as it cools. Composition determines the magnitude of solidification-contraction (or expansion), whilst all of the variables may influence the way in which it acts and the distribution of solidifying metal in the casting. This brief description indicates the scope of the problem, and the remainder of the Paper contains details of the individual effects of the variables, so far as information is available. In most cases, an attempt has been made to explain the observations in terms of the three major factors mentioned above, but in some cases this has not been possible.

Types of Defects

The following types of shrinkage defect have been studied:—(*a*) *Dispersed porosity;* this is also referred to as internal porosity and consists of innumerable minute cavities, clearly visible in fractures or etched surfaces. (*b*) *Internal cavities;* the term is self-explanatory; a typical defect is shown in Fig. 1. (*c*) *Sinks;* these are shallow surface depressions, illustrated in Fig. 2 together with (*d*) *draws,* the latter being deep, narrow surface depressions. The distinction between the last two defects is a purely arbitrary one.

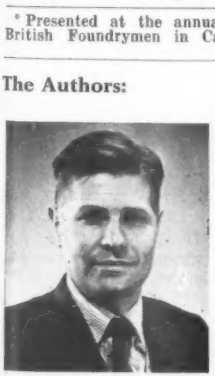
Influence of Variables

Pouring Temperature.

Raising the pouring temperature increases the total amount of liquid-contraction which occurs before the commencement of solidification. It also slows down the rate of solidification, by causing the mould temperature to rise appreciably, before solidification starts. One might anticipate from this that castings poured with hot metal would exhibit the least chill, but Williams[1,2] has shown the reverse to be the case. This indicates an effect of pouring temperature on the mechanism of eutectic solidification, increased pouring temperature tending to favour eutectic-carbide formation. Primary-austenite solidification is also affected, and

* Presented at the annual conference of the Institute of British Foundrymen in Cardiff last month.

The Authors:



MR. I. C. H. HUGHES, M.SC., A.I.M., joined the Soundness of Castings Research Team of the British Cast Iron Research Association in 1954, and is now assistant to the research manager. Born in 1925, he was educated at Bembridge School, Isle of Wight, Portsmouth Municipal College and Swansea University College, where he graduated with first class honours in metallurgy in 1946. Until 1954 he was employed by the Mond Nickel Company, Limited, as research metallurgist. In 1953, he was awarded the degree of M.SC., for work on the solidification of cast iron.

MR. J. H. GITTUS, B.SC., is employed at the Birmingham laboratories of the Mond Nickel Company, Limited, as section leader of the department engaged in cast iron research. He was born in 1930 and educated at Alcester Grammar School. In 1946 he joined the British Cast Iron Research Association as an apprentice, and in 1950, having obtained an external degree from London University, became a member of the Association's research staff. In 1953, Mr. Gittus was awarded a Fellowship of the Worshipful Company of Founders for work on nodular-iron castings.

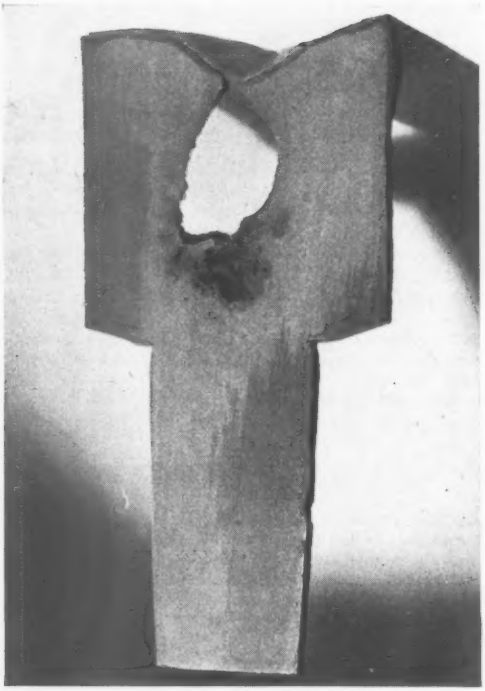


FIG. 1.—*Slice cut from a casting containing an internal cavity.*

Norbury[17] has shown that dendrites are longest in castings poured at high temperatures. Several workers have studied the influence of pouring temperatures on shrinkage defects, amongst them Timmons,[3] who found that the total volume of internal cavities in 4-in. cubes increased as the pouring temperature rose. Cavity volume was computed from a comparison of the real and apparent densities of the castings, and the results are plotted in Fig. 3.

A study has been made recently at the British Cast Iron Research Association of the influence of pouring temperature on the size, type and location of shrinkage defects in K-bar test castings made in various irons.[4] Fig. 4 is a drawing of the pattern from which the test castings were produced, and the results are summarized in Figs. 5, 6, and 7.

Fig. 5 shows that the percentage of K-bars exhibiting porous fractures increased with increasing pouring temperature. This diagram is based on observations of 144 castings, the compositions of which varied over the following ranges:—Total carbon, 3.62 to 3.26; silicon, 2.30 to 1.75; manganese, 0.60 to 0.40; sulphur, 0.040 to 0.056; and phosphorus, 0.35 to 1.10 per cent.

Fig. 6, on the other hand, shows that the total volume of external shrinkage in a series of K-bars diminished as the pouring temperature rose. Points on this diagram represent measurements made on over 300 castings, by filling the visible cavities with a measured volume of dry silica sand. The composition lay within the following limits:—T.C, 2.98 to 2.64; Si, 2.25 to 1.48; Mn, 0.67 to 0.42; S, 0.119 to 0.052; and P, 0.91 to 0.56 per cent. The positions of the surface shrinkage defects were also recorded, and the results are shown in Fig. 7, in which a distinction has been made between sinks and draws (see Fig. 2).

The following conclusions may be drawn about the influence of pouring temperature on shrinkage in K-bars:—(*a*) K-bars poured at high temperatures were prone to contain internal porosity. The total volume of external shrinkage in such castings was small and usually comprised deep draws at the re-entrant angles; and (*b*) K-bars poured at low temperatures contained little porosity. The total volume of external shrinkage was comparatively large, and usually took the form of shallow sinks.

It is not easy to advance a coherent hypothesis to explain all of these observations. Quite clearly, the tendency is for the shrinkage defects to move from the exterior to the interior of the casting, as the pouring temperature rises, and it is likely that a careful study of the initial rate of solidification of the surface of the casting might provide an explanation.

Composition.

Elements well-known to influence shrinkage are carbon, silicon and phosphorus; other important major elements in grey iron are manganese and sulphur, which may have an effect upon soundness:

Carbon.—Raising the carbon content of hypo-eutectic grey iron lowers the temperature at which solidification commences and therefore increases the amount of liquid shrinkage for metal poured at a given temperature. At the same time, the solidification contraction is reduced, since the amount of primary austenite (whose solidification is accompanied by a contraction) is decreased by raising the carbon content of the iron. When primary-austenite solidification is complete, the remaining liquid metal freezes as a graphite-austenite eutectic, with an accompanying expansion. The amount of eutectic, and therefore the extent of this expansion, is increased by an increase in carbon content.

Experiments have confirmed that the total (primary-austenite plus eutectic) solidification-contraction is reduced by raising the carbon content.[5,6] Raising the carbon content also diminishes the temperature range over which solidification occurs, and castings of high carbon-content tend to solidify by the growth of a skin of solid metal, whereas in those of lower carbon-content, solidification is occurring simultaneously in all regions at all times, although it is always most advanced at the surface. Dispersed solidification causes dispersed porosity, so that although raising the carbon content decreases the total amount of solidification-contraction, it reduces the tendency for any resulting shrinkage defects to be dispersed.

It might therefore be anticipated that if a series of hypo-eutectic castings were made at different carbon-contents, those of the lowest carbon-con-

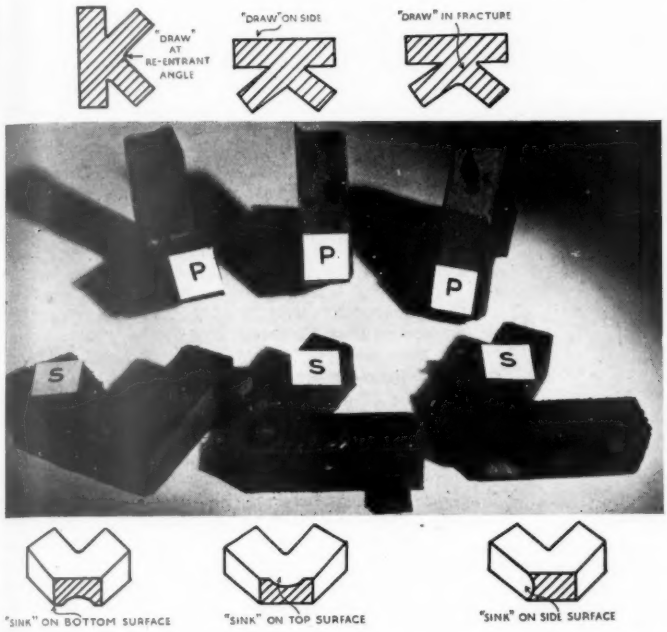


FIG. 2.—*Typical sinks and draws: s = sink, p = draw.*

tent would contain an extensive region of porosity whilst those of higher carbon-content would contain local cavities of smaller total volume. Results reported in the literature partially support this, and some photographs of sectioned motor-cylinder heads,[7] 3-in. spheres[8] and 4-in. cubes[9] show that local shrinkage cavities appear when the carbon content of the metal is raised. However, the dispersed porosity which might be anticipated in the castings of lower carbon-content was not observed by the authors of these papers. In fact, Jeffrey and co-workers[5] *computed* the total volume of internal shrinkage cavities from density measurements, and found that this diminished with diminishing carbon, although one would expect it to increase.

In hyper-eutectic irons, however, pro-eutectic graphite is precipitated as the first stage solidification, which partly compensates liquid shrinkage. With increasing carbon-content, the range of temperature of this graphite formation is extended by an increase in the temperature at which solidification starts. It is therefore to be expected that increasing the carbon-content of hyper-eutectic iron would decrease its total shrinkage. Some workers have, nevertheless, found a decrease in soundness with increased carbon-contents above the eutectic value.[7 8 9]

TABLE I.—*Effect of Carbon Content (per cent.) upon the incidence of Porosity in K-bar Castings.*

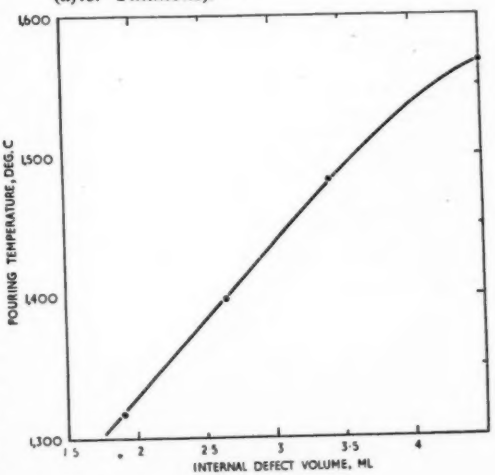
Carbon	3.78	3.2	2.65
Porous Castings per cent	33	63	100

A few experiments made at the laboratories of the British Cast Iron Research Association[4] definitely show that low carbon-content favours the formation of finely-dispersed porosity in hypo-eutectic K-bars (Fig. 4). The results are summarized in Table I and refer to a series of melts within the following range of composition, etc.:—T.C, 3.78 to 2.65; Si, 1.86 to 1.91; Mn, 0.42 to 0.51; S, 0.109 to 0.140; and P, 0.036 to 0.86 per cent. Pouring temperatures from 1,440 to 1,250 deg. C. All castings made in duplicate green- and dry-sand moulds.

Silicon.—Silicon has much the same effect as carbon, although a larger variation in silicon than in carbon is required to effect any specific change in the solidification sequence. Thus, raising the silicon content decreases the temperature of initial solidification, the temperature interval over which solidification occurs, and the amount of primary austenite. It increases the amount of eutectic, but reduces the solidification expansion (expressed in this case as a percentage of the total amount of eutectic formed) by reducing the percentage of graphite in the eutectic. Investigators have found that raising the silicon content has an effect on shrinkage defects similar to that obtained by raising the carbon[7 8 9].

Manganese.—Nothing appears to have been pub-

FIG. 3.—*Influence of pouring temperature on the total volume of internal cavities in 4-in. cubes (after Timmons).*



lished concerning the influence of manganese on shrinkage defects. However, the examination of records provided by two foundries suggested that an effect existed, and accordingly the Authors carried out some experiments in which K-bars and also $\frac{5}{8}$-in. plates surmounted by heavy bosses (Fig. 8) were cast in metal of various manganese-contents. The K-bars were examined for sinks, draws and internal porosity. The depths of the sinks which formed on the plates, under the

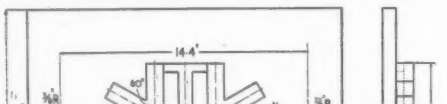


FIG. 4.—*Patternplate from which the K-bar test samples were produced. Dimension A = 4½ in.*

TABLE II.—*Influence of Manganese on Porosity in K-bars and Sinking under Bosses. Base composition: T.C. 3.1, Si 2.9, S 0.07, P 1.0, Ti 0.05. per cent.**

Manganese per cent.	0.36	0.73	0.90	1.14	1.40	1.47
No. of porous K-bars	6	4	1	0	0	0
Depths of sink, $\times 10^{-3}$ in.	2.1	1.0	0.6	0.1	—0.1 (bulge)	—0.2 (bulge)

* Six K-bars and one plate were cast at each manganese content.

bosses, were measured to 0.001 in. with a spherometer. Results are given in Table II and indicate that raising the manganese content has eliminated porosity in the K-bars and sinking in the plates. No reason for this effect can yet be advanced, but it has considerable practical importance, since it does not appear to have previously been suspected.

Sulphur.—No information is available about the influence of sulphur on shrinkage defects, but since manganese has been found to have an effect upon soundness, it is likely that sulphur also plays some part, and there is an obvious need for investigation of the simultaneous effect of manganese and sulphur.

Phosphorus.—It is well known that castings of high phosphorus-content are the most prone to contain internal porosity. This is supported by

TABLE III.—*Influence of Phosphorus on Porosity in K-bars of various Carbon-contents.*

Phosphorus per cent	Carbon per cent.		
	2.65	3.2	3.8
0.05	6	0	0
0.15	6	3	0
0.30	6	6	3
0.85	6	6	5

Figures in body of table indicate the number of castings having porous fractures, out of a possible six. The base metal composition was: Si. 1.8, Mn. 0.6, and S. 0.1 per cent.

previous publications[7,8] and by work recently carried out in the B.C.I.R.A. laboratories[4] which is summarized in Table III. K-bars were produced at varying phosphorus- and carbon-contents and examined for porosity. The six castings produced at each analysis were cast at 1,400, 1,360 and 1,250 deg. C. into duplicate green- and dry-sand moulds. The results in Table III clearly indicate that the amount of phosphorus required to produce porosity was reduced by a reduction in carbon content. Irons containing phosphorus are widely employed so that the pronounced effect of this element on shrinkage defects is of general interest.

With this in mind, the Authors have recently investigated the reasons for the effect of phosphorus on porosity[10]. To this end, a study has been made of the way in which iron castings of high phosphorus-content solidify. The castings were 2-in. dia., 8-in. long, solid, round bars. They were cast vertically in green-sand and bottom gated. A number of these were produced simultaneously in metal innoculated with ½ per cent. silicon in the form of a ladle addition of 80 per cent. silicon ferro-silicon poured at between 1,360 and 1,370 deg. C. The percentage composition of the metal is given as: T.C. 3.24; Si 1.96; Mn 0.67; S 0.104; and P 1.19 per cent. Thermocouples placed at various positions in the cross-section at midlength of one of the castings were employed to record the cooling conditions, yielding the isotherms shown in Fig. 9. The advantage of such a diagram over the original cooling curves has been described

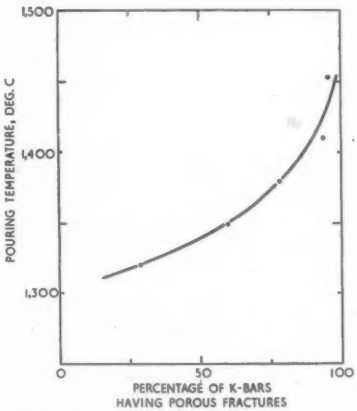


FIG. 5.—*Effect of pouring temperature on porosity in K-bars.*

by Pellini and co-workers[11] and by Hughes [12] Fig. 9 indicates that the main eutectic arrest occurs at about 1,103 deg. C. and the phosphide-eutectic arrest at 927 deg. C.

In addition to the casting on which temperature measurements were made, some others exactly similar in all respects were quenched into water during their solidification. Micro-specimens cut from these castings were examined and the amount of eutectic which had solidified in various zones,

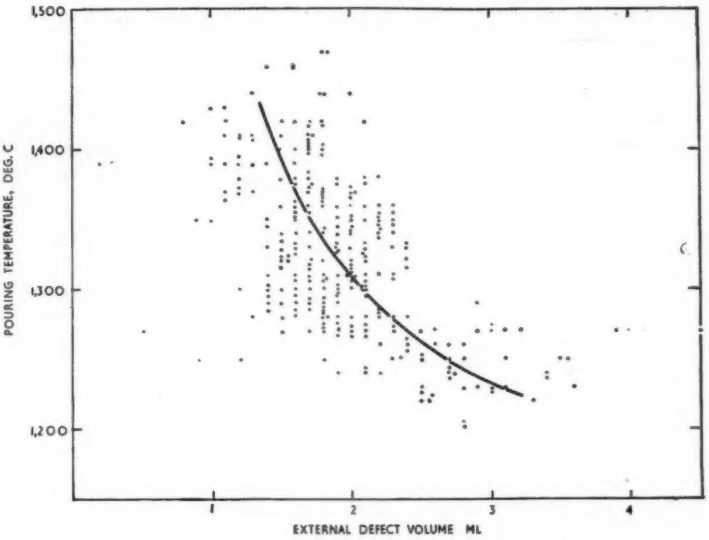


FIG. 6.—*Effect of pouring temperature on external shrinkage in K-bars.*

at different times after the castings were poured, was estimated by lineal and areal analysis. The results of these studies are superimposed in Fig. 10 on the isothermal diagram, previously mentioned. This indicates that solidification was substantially confined to the actual arrest temperatures. Between 50 and 60 per cent. of the eutectic liquid solidified as a graphite/austenite eutectic during the first temperature arrest, and about 32 per cent. solidified as a phosphide eutectic at the second arrest. Between 1,103 and 927 deg. C. at least 32 per cent. of liquid was present in all parts of the casting. It took the form of an irregular network.

These observations may account for the formation of porosity in phosphoric-iron castings since:—(1) The addition of phosphorus caused the eutectic to solidify in two stages. In the first stage, the normal graphite-eutectic formed, followed by the phosphide eutectic in the second stage. Regardless of the total amount of eutectic in the iron, increasing the phosphorus content would increase the phosphide eutectic and decrease the graphite-austenite proportion in eutectic. Only the solidification of the graphite-austenite eutectic is accompanied by an expansion which might be expected to act partially to displace liquid metal into any porosity formed during primary-austenite solidification. Clearly, the extent to which this can occur depends on the amount of the graphite-austenite eutectic. The effect of carbon on the amount of phosphorus needed to cause porosity (Table III) could be explained in this way, if lowering the carbon content and raising the phosphorus content both reduce the proportion of austenite-graphite eutectic. (2) The liquid metal, present as the casting cools from the first to the second arrest, may contract more rapidly than the surrounding solid. This could cause porosity. (3) The phosphide eutectic itself may freeze with a contraction.

Mechanism of Solidification

Metal composition influences shrinkage because it determines the amount and type of the constituents formed during solidification. An additional factor is the way in which the constituents solidify, which is not necessarily determined by composition alone. A good example of the influence of the mechanism of eutectic solidification on shrinkage is afforded by a comparison of flake- and nodular-graphite cast-irons. Nodular irons shrink to a much greater extent than flake-graphite irons of virtually similar composition. Timmins[8] reported a pronounced effect of graphite size in flake-graphite irons. Fine graphite, produced by the titanium/CO_2 process*, was always associated with the absence of internal porosity in 3-in. spheres, a fact confirmed by West and Hodgson[12]. Conversely, coarse graphite produced by melting in contact with coke in a crucible furnace, caused pronounced porosity[8].

These examples clearly indicate the effect of the mechanism of eutectic solidification, as distinct from the effect of base-composition. However, altering the composition also alters the mechanism of solidification, and the effect of this alteration will be superimposed on other effects of composition. What the results of this will be, it is impossible to say, but it is noteworthy that graphite size increases with the Carbon Equivalent. This may indicate that the irons examined were in varying states of inoculation and so partially explain the results of Jeffrey and co-workers[9] who found that the amount of internal porosity in 4-in. cubes was increased by raising the Carbon Equivalent. Their finding is certainly very difficult to explain in terms of composition alone.

The Authors have investigated certain aspects of the influence of the mechanism of solidification on shrinkage, particularly the effects of furnace temperature and inoculation. In addition, a detailed study of nodular irons has been made. The results of these studies are presented below.

Inoculation and Furnace Temperature

Influence of inoculation on sinking.—The depth of sink under the bosses on the plate casting pre-

* Process developed at the BCIRA of gassing molten cast iron with CO_2 after prior addition of titanium, with the objective of graphite refinement.—Editor.

TABLE IV.—*Summary of Effects of Inoculation upon Depths of Sink under Bosses on Plates 5/16-in. thick. Composition ranges: C 2.72 to 3.89; Si 1.88 to 3.74; P 0.031 to 1.66; and C.E. 3.47 to 4.67 per cent.*

	Depths of Sink × 10^{-3} inches Inoculated	Untreated
Mean	3.14	2.13
Range—upper	11.42	7.41
lower	0.75	—0.3
No. of experiments ..	55	36

viously described (Fig. 8) was measured, for castings, a proportion of which had been inoculated by a ladle addition of 0.5 per cent. silicon as 80 per cent. silicon ferro-silicon. The results are summarized in Table IV, and show that inoculation has increased the average depth of sink markedly. The extreme values are also influenced, and in fact, some of the uninoculated castings exhibited bulges in places of sinks. These results represent an extension of previous work[13]. Inoculation with graphite has been found to have a similar effect.

It is interesting to record that in some of the low phosphorus castings, notably those in the following composition range: T.C. 2.66 to 3.09; Si 1.88 to 2,74; Mn 0.59 to 0.80; S 0.032 to 0.105; P 0.026 to 0.041; and Ti 0.015 to 0.06 per cent., exudations frequently occurred, under and around the bosses. These exudations were only found in the uninoculated castings.

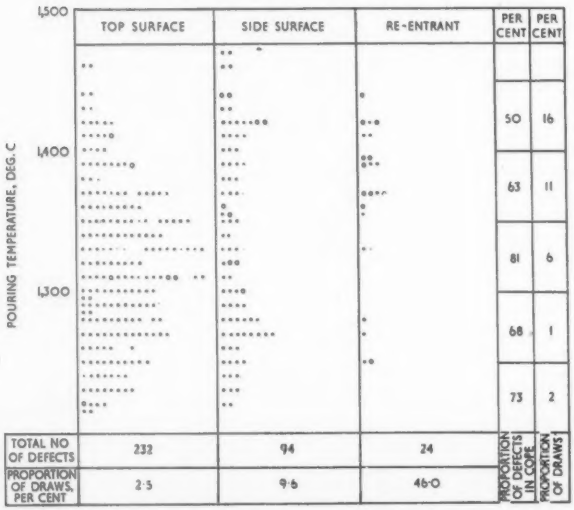
Inoculation, Furnace Temperature and Porosity.—The K-bar (Fig. 4) was used to study porosity. Table V shows the effect of inoculation with ferro-silicon, which has tended to produce porosity. Inoculation was achieved by adding ferro-silicon to the furnace shortly before tapping. Treated castings were poured from the same furnace 30 min. later, when the inoculation would have faded considerably.

FIG. 8.—*Plate, $\frac{5}{16}$-in. thick, with bosses on the top surface.*

Table VI shows the percentage of K-bars, poured from a furnace whose temperature was rising, which were porous at various furnace temperatures. Raising the furnace temperature reduced the percentage of porous castings from 100 to 25. Most of the castings also exhibited sinks, which often contained exudations of the type found in plates, especially in castings which did not contain porosity. This is recorded in Table VI.

These results, both for sinking in plates and porosity in K-bars, suggest that inoculation reduces the tendency for eutectic solidification-expansion to displace liquid metal into porosity. Conversely, high furnace-temperatures increase this tendency so that porosity is eliminated. In extreme cases, so much liquid metal is displaced by the expansion that it cannot all be accommodated in the previously-formed porosity, and is therefore exuded through the skin of the casting.

FIG. 7.—*Effect of pouring temperature on position and type of shrinkage defects in K-bars. Key: o=draw, • = sink.*



Shrinkage Defects in Nodular-graphite Irons.

The solidification sequence of nodular-graphite irons has been described in the literature[14] and the high shrinkage characteristics of these irons are well known. Some additional experiments have been performed to obtain more information upon the shrinkage and the solidification sequence of nodular-graphite iron castings. A number of 3-in. dia. spheres were made in green- and dry-sand moulds using nodular- and flake-graphite irons of nearly identical major compositions, as shown in Table VII. The design of test-piece was similar to that used by Timmins. The volumes of the surface shrinkage defects in the resulting castings were measured by determining the volume of clean dry sand required to fill them. In addition, their average horizontal diameters and their weights were measured. The results are given in

TABLE V.—*Porosity in Duplicate Castings, Inoculated and Untreated.* (*P*=*porous. PP*=*very porous.*)

Carbon per cent.	Pouring Temp. deg. C.	Mould Type	State of Metal				Base Composition			
			Inoculated		Untreated		Si	Mn	S	P
3.7	1440	"Green"	P	PP	P		1.91	0.50	0.121	0.51
		Dry		PP	P					
	1350	"Green"	PP	P	P	P				
		Dry	P							
	1260	"Green"	PP	P	P	PP				
		Dry				P				
3.0	1440	"Green"	PP	PP			1.85	0.52	0.128	0.48
		Dry	PP	PP						
	1350	"Green"	PP	PP						
		Dry	PP	PP						
	1260	"Green"	P	P						
		Dry	PP							
2.6	1440	"Green"	PP	PP	P	PP	1.87	0.51	0.136	0.48
		Dry	PP	PP						
	1350	"Green"	PP	PP	P					
		Dry	P	P						
	1260	"Green"	PP	PP						
		Dry		P						
Per cent. Porous:			83		28					

Table VIII which records the mean values of sets of six castings. The nodular-graphite iron castings were lighter and contained larger defects than the flake-graphite irons, while castings moulded in green-sand were heavier, larger, and contained larger defects than those moulded in dry sand.

To test whether the differences in sizes of the flake- and nodular-graphite iron castings were related with the differences in volumes of the shrinkage defects, measurements were made to determine the time at which dimensional changes occurred, capable of causing the observed discrepancies.

TABLE VI.—*Effect of Furnace History on Porosity in K-bars.*

Furnace temperature deg. C.	1,470	1,440	1,410	1,380
Per cent. porous	25	80	94	100
No. cast	24	20	16	12
Per cent. containing exudations	46	24	13	8

Compositions referred to in Table VI.

Melt No.	Composition per cent.					
	T.C.	Si	Mn	S	P	CE
1	3.62	1.9	0.53	0.056	0.35	4.37
2	3.52	1.78	0.56	0.049	0.49	4.28
3	3.33	1.68	0.52	0.050	0.99	4.22
4	3.41	2.22	0.53	0.060	0.36	4.27

Pouring temperatures used for castings described in Table VI.

Furnace temperature deg. C.	Pouring temperature, deg. C.					
1,380	1,270	1,300	1,330	—	—	—
1,410	1,270	1,300	1,330	1,360	—	—
1,440	1,270	1,300	1,330	1,360	1,390	—
1,470	1,270	1,300	1,330	1,360	1,390	1,420

TABLE VII.—*Compositions of Flake- and Nodular-graphite Iron Spheres.*

Type of iron.	Composition (per cent.)						
	T.C.	Si	Mn	S	P	Ni	Mg
Flake ..	3.46	2.17	0.65	0.028	0.027	0.62	—
Nodular ..	3.35	2.04	0.65	0.025	0.024	0.60	0.068
Flake ..	3.41	2.15	0.63	0.031	0.028	0.62	—
Nodular ..	3.44	2.08	0.63	0.031	0.026	0.54	0.058

Two horizontally-moulded 6-in. long by 4-in. dia. solid bars were cast in the green-sand moulds from a flake- and a nodular-graphite iron of compositions similar to those quoted in Table VII. Measuring probes in the form of thin silica rods terminating in the plane ends of the castings and attached to dial gauges were employed to record changes in casting length during cooling in 0.001-in. steps. The results, shown in Fig. 11, indicate clearly the very much greater expansion of nodular-graphite iron castings during eutectic solidification. It is suggested that this difference could account for the different shrinkage characteristics of the two types of iron and that whereas eutectic solidi-

TABLE VIII.—*Characteristic Measurements on Flake- and Nodular-graphite Iron Spheres.*

Type of iron.	Type of mould.	Defect volume ml.	Diameter mm.	Weight lb. oz.
Flake ..	"Green" ..	4.6	90.1	5 12.104
	Dry ..	0.8	88.2	5 9.625
Nodular ..	"Green" ..	8.6	90.4	5 11.187
	Dry ..	4.2	87.6	5 9.520

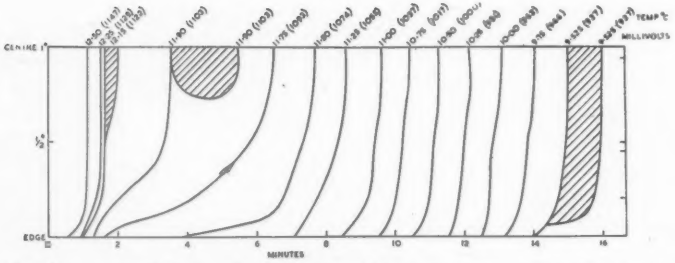


FIG. 9.—*Isotherms for flake-graphite iron containing phosphorus.*

fication expansion in the flake-graphite iron can displace liquid metal into any initially-formed shrinkage defects, in the nodular-graphite iron it acts mainly to expand the casting, together with any shrinkage defects which the latter may contain. This hypothesis is attractive, for it explains not only why nodular-graphite irons are so much more prone to contain shrinkage defects than their flake-graphite counterparts, but also why the former are so hard to feed.

Mechanism of Eutectice Solidification in Nodular-graphite Iron Castings.—To obtain information on the origin of the relatively-large, eutectic-stage expansion of nodular-graphite iron castings, a detailed examination of the mechanism of eutectic solidification in such castings and in flake-graphite iron castings were made. A number of 2-in. dia., 8-in. high bars were cast vertically in green-sand moulds in a flake- and a nodular-graphite hypo-eutectic inoculated iron having the compositions given in Table IX. The bars of each series were

TABLE IX.—*Percentage Compositions of Nodular- and Flake-graphite Irons used for Quenching Experiments.*

Type of iron.	T.C.	Si	Mn	S	P	Ni	Mg
Flake graphite..	3.21	2.28	0.41	0.052	0.062	—	—
Nodular graphite	2.96	1.93	0.35	0.058	0.049	0.65	0.062

poured together at 1,360 to 1,370 deg. C. and, in the manner described above for phosphoric irons, they were quenched into water at various times after pouring, with the exceptions of one bar of each series in which thermocouples were inserted at the mid-length cross-section and which were allowed to solidify normally. The amount of liquid present throughout the central cross-section of each bar at the time of quench was assessed from microscopical examination and the thermal conditions in the bars at all times during normal solidification were recorded. The results are set out in Figs. 12 to 17.

Figs. 12 and 13 illustrate the as-cast structures of normally-solidified bars of the two materials. Figs. 14 and 15 illustrate typical structures in partially-solidified, quenched bars from which percentage solid curves were deduced. Fig. 14 shows a point in a quenched bar of the flake-graphite iron at which approximately 30 per cent. of solid eutectic was present at the time of quenching. Two eutectic cells are seen surrounded by finely-dispersed, graphite-austenite eutectic formed by rapid solidification of liquid. Fig. 15 shows a point in a nodular-iron casting at which approximately 15 per cent. of solid eutectic was present at the time of quenching. Each nodule is the centre of a small individual cell having a surrounding austenite envelope. Eutectic, which was liquid at the time of quenching, has solidified as finely-dispersed, iron-carbide eutectic.

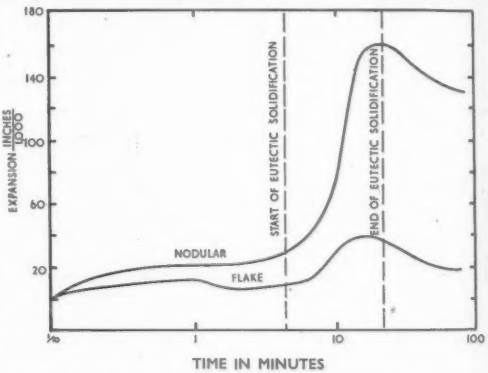


FIG. 11.—*Expansion of nodular- and flake-graphite castings during solidification.*

The number of eutectic cells per unit volume was much greater in the nodular-graphite iron than in the flake-graphite iron, as mentioned earlier.

The distribution of solid eutectic at various times across the central cross-section of the bars is shown graphically in Figs. 16 (flake) and 17 (nodular), which are interpreted as follows:—In the flake-graphite iron, a shell of solid eutectic formed on the outside of the casting at an early time and gradually thickened during eutectic solidification.

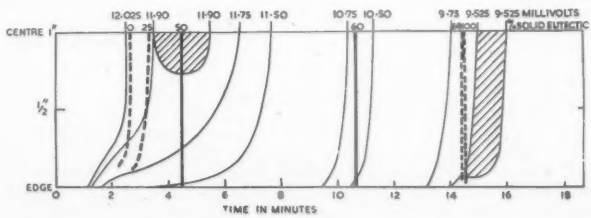
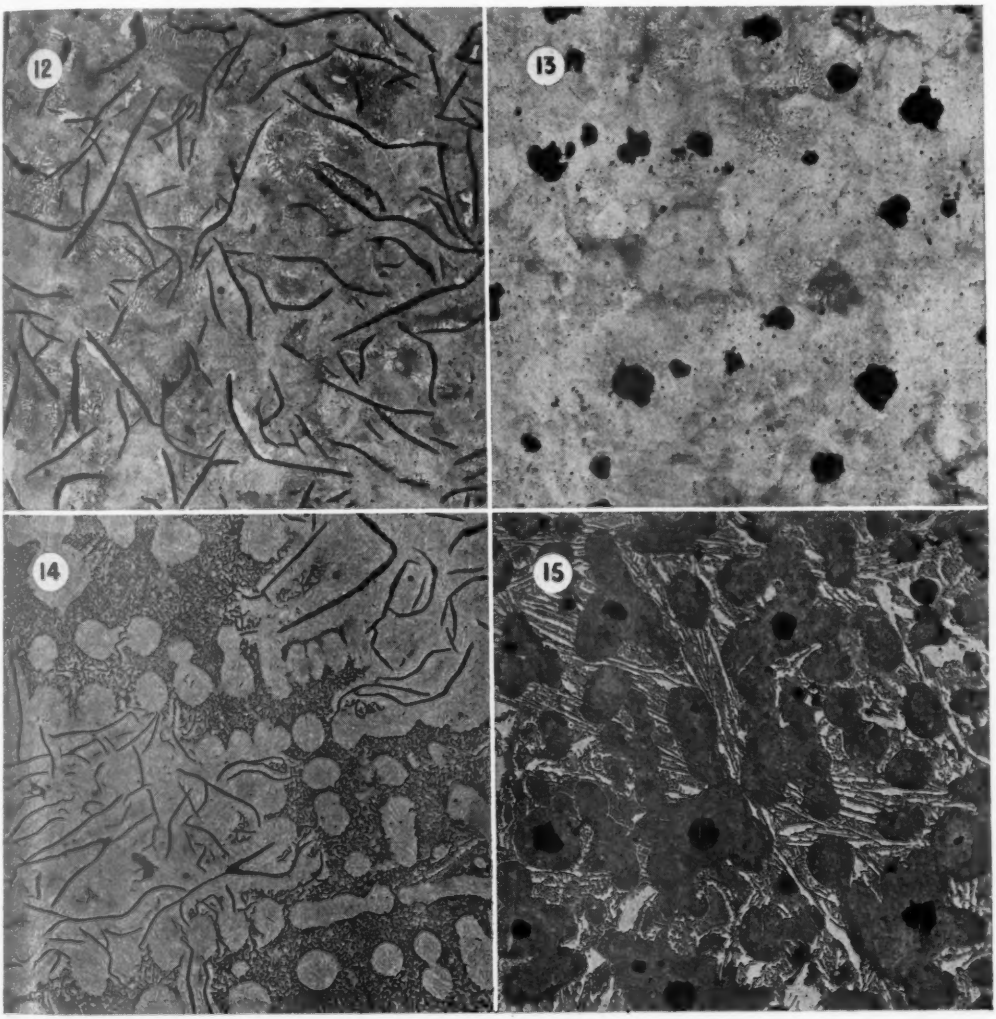


FIG. 10.—*Comparison of isotherms (fine lines) and percentages of solid eutectic (bold lines) for flake-graphite iron containing phosphorus.*

At the same time, some solidification was occurring in the interior of the casting: for example, curve C in Fig. 16 shows that the casting quenched four minutes after pouring had a solid skin about $\frac{3}{16}$ in. thick with about 15 per cent. of solid eutectic at the centre. After $1\frac{1}{2}$ minutes (curve D) the skin was nearly $\frac{1}{2}$-in. thick and approximately 40 per cent. of the eutectic at the centre was solid.

In the nodular-graphite iron, however, solidification progress was entirely different (Fig. 17) and liquid metal was present throughout the casting during practically the entire period of solidification. For example, curve C in Fig. 17 shows that 75 per cent. only of the eutectic was solid at the edge of the casting quenched four minutes after pouring, and even after a further six minutes had elapsed (curve G) the edge of the casting was still not completely solid.

FIGS. 12 TO 15.—*Microstructures of various test-bars, all etched in* 4 *per cent. picral and* ×100. FIGS. 12 AND 13 *are respectively flake- and nodular-graphite irons which have solidified normally.* FIG. 14.—*Quench structure of partially solidified flake-graphite iron in which* 30 *per cent. of the eutectic had solidified.* FIG. 15.—*Quench structure of partially solidified nodular-graphite iron in which* 15 *per cent. of the eutectic had solidified.*



To summarize, the flake-graphite eutectic solidified by growth of large eutectic cells inside a continuously-thickening, solid shell, whereas the nodular-graphite eutectic was solidifying at practically all times in most parts of the casting. It is suggested that in this difference lies the reason for the marked expansion of nodular-graphite iron castings during eutectic solidification, and for their tendency to form shrinkage defects, and the possible mechanism will next be dealt with.

During eutectic solidification, the nodular-graphite iron casting may at any time be considered

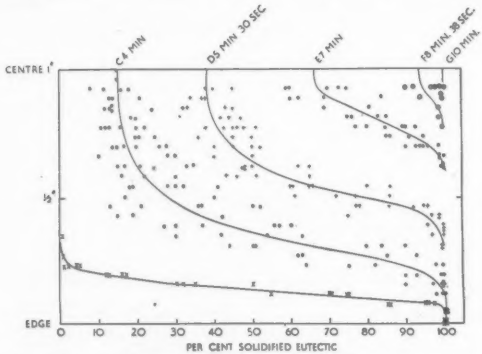


FIG. 16.—*Distribution of solidified eutectic in flake-graphite castings at various times during solidification.*

as a coherent block of solidified metal, honeycombed from edge to centre by solidifying liquid. The liquid solidifies by the diffusion of carbon through the austenite to the graphite nodules and the deposition of austenite on their periphery.[14] This process involves continual expansion of the cells, which occurs simultaneously throughout the casting and a general expansion results, accompanied by enlargement of the casting and of any internal voids, and possibly in the formation of fresh cavities. On the other hand, since most of the large cells of eutectic in the flake-graphite iron are surrounded by liquid, or are growing freely into liquid eutectic, it is difficult to see how their solidification (if accompanied by expansion) can do other than displace liquid into any previously-formed shrinkage defects, at least until the last stages of solidification are reached. The small expansion observed in flake-graphite iron castings during their solidification may be due to graphitization of the last traces of liquid in the almost solid shell. A schematic diagram, which may assist in the appreciation of this hypothesis, is shown in Fig. 18.

It is not the primary object of this Paper to speculate upon the reasons for the marked difference in eutectic solidification in flake- and nodular-graphite iron castings, but it is worth noting that whereas eutectic graphite in nodular irons is at all times insulated from the melt by austenite envelopes, in flake-graphite irons, the tips of the growing flakes are in contact with the liquid[15]. This modified mechanism in nodular-graphite irons would be expected to result in a decrease in the rate of carbon diffusion and latent heat evolution with consequent retardation in freezing rate and increased eutectic freezing range. This is in keeping with the observation above that eutectic solidification occurred over a wider band in the nodular-graphite than in the flake-graphite iron casting.

Influence of Design on Shrinkage Defects

It is essential to recognize that the results obtained from any investigation of shrinkage defects will not necessarily apply to all types of

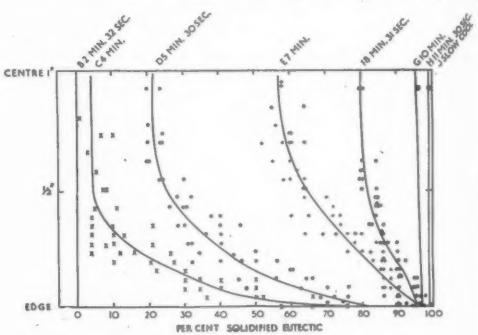


FIG. 17.—*Distribution of solidified eutectic in nodular-graphite castings at various times during solidification.*

casting. The design and appearance of iron castings probably constitutes the most important variable where shrinkage defects are concerned.

Timmins[8] has shown that thin castings, having a low volume:surface-area ratio, contain less porosity than castings with a higher volume:surface-area ratio. This effect may be similar to that

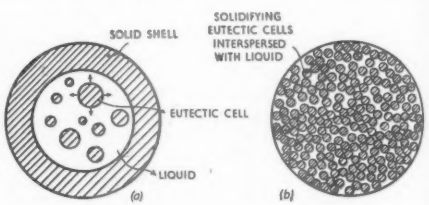


FIG. 18.—*Expansion of flake-graphite (a) and nodular-iron eutectics (b).* In (*a*), isolated eutectic cells can displace liquid metal into any initially-formed shrinkage voids. In (*b*), expansion of many neighbouring eutectic cells causes expansion of the casting as a whole.

reported earlier (Fig. 5) for the effect of increasing the pouring temperature. High volume:surface ratios and high pouring temperatures both cause slow solidification, both associated with porosity.

In recent work carried out in the Authors' laboratory by Szajda[16] a series of K-bars half, two-thirds, five-sixths the size and the same size as those

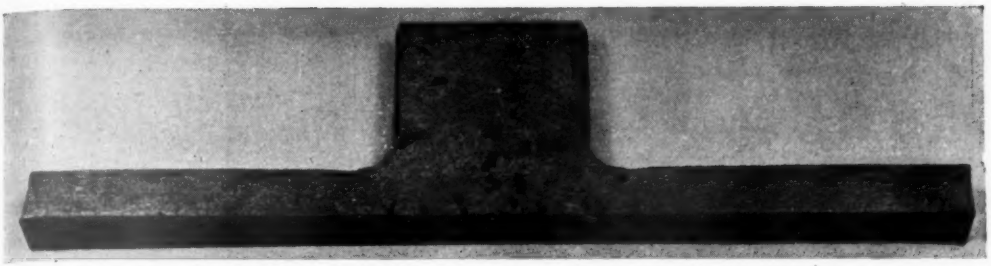


FIG. 19.—*Sub-surface gas bubbles in a section cut from a test casting, approximately full size.*

shown in Fig. 4 were cast in metal of the following percentage compositions: T.C. 3.70 to 2.28; Si 2.06 to 1.80; Mn 0.45 to 0.54; S 0.13 to 0.18; and P 0.059 to 1.46 per cent. The results are recorded in

TABLE X.—*Effect of K-bar Size on Shrinkage Defects.*

Size of casting.	A (largest).	B	C	D (smallest)
Number made ..	36	36	35	36
Number drawn ..	0	1	7	0
Number porous ..	22	27	21	18

Table X and show that the least porosity was found in the smallest castings. "Drawing" was most pronounced in casting C (two-thirds full size), a fact which has subsequently been fully confirmed. This is in keeping with the practical experience that certain castings are more prone to draw than others, for obscure reasons.

Influence of Gas on Shrinkage

Little definite information has been published concerning the effects of dissolved gases upon shrinkage in iron castings. It is known that the solubility of hydrogen and nitrogen decrease sharply at the melting point and it might be expected that castings produced from irons containing increased gas contents would tend to contain internal porosity rather than external sinks. However, experiments carried out at the British Cast Iron Research Association on normal, unalloyed, grey cast-irons have failed to show any effect of nitrogen or oxygen in amounts commonly found in cast irons. Only when contents of these elements many times greater than those occurring in industrial practice have been studied, has an effect been observed on porosity. Hydrogen may have an effect on soundness when present in amounts sometimes found commercially. Characteristic gas-unsoundness is illustrated in Figs. 19 and 20. Fig. 19 shows porosity in a boss on a thin plate, believed to be due to nitrogen and hydrogen, and Fig. 20 shows the effect of high nitrogen-content in a test-bar casting.

Nevertheless, some foundrymen are convinced, as the result of their practical observations, that gases play a part in determining the soundness of their castings. Frequently, however, the conditions believed to have led to high gas-contents involve super-heating or other modifications to furnace history which, it is shown above, may have pronounced effects upon soundness for quite different reasons.

Feeding Iron Castings

One method of eliminating shrinkage defects is by supplying liquid metal to compensate shrinkage as it occurs. This approach is not nearly so widely employed with cast iron as with many other metals, because the expansion accompanying the solidification of the graphite/austenite eutectic often renders it unnecessary. In fact, even in cast irons which do require feeding, much of the information which has been obtained for steels and non-ferrous alloys is inapplicable. For example, it is widely held (and correctly so for most metals, including steel castings) that the feeder must solidify after the casting. This is to ensure that metal will drain from the feeder into the casting until the latter is solid. All shrinkage will then occur as a cavity in the feeder. However, many feeders employed in low-phosphorus, grey-iron practice are much too small to fulfil this requirement, but nevertheless they are evidently satisfactory. The reason for this lies in the two-stage solidification process of the iron. The primary-austenite solidification is accompanied by a contraction and eutectic solidification by an expansion. Hence, a feeder need only be sufficiently large to be able to provide liquid metal while primary austenite is solidifying in the casting, so that it can be completely solid during the major part of eutectic solidification in the casting.

In phosphoric irons, however, a final shrinkage stage occurs so that liquid feed metal is required by the casting after the normal eutectic solidification is largely completed. Here, a large feeder is required which will solidify after the casting.

An exception to the behaviour of low-phosphorus, grey irons is the recently developed nodular-graphite iron, in which, as the Authors have shown, shrinkage defects form during eutectic solidification. Successful feeders for nodular castings must therefore solidify after eutectic solidification in the casting is complete.

Conclusions

Some of the features of the solidification and soundness of grey-iron castings which may be concluded both from the literature and the experi-

FIG. 20.—*Gas porosity in a 1.2-in. dia. bar of grey cast iron.* ×3¼.

ments described are summarized as follows:—

(*a*) Soundness is affected by the composition of the iron in a way which is by no means clearly established. Carbon, which would be expected to play a major rôle in governing solidification volume changes, can vary with soundness in two ways at least. In K-bars, increasing the carbon-content has been found to decrease internal-porosity, whereas in unfed spheres and cubes, a corresponding increase in internal porosity has been reported in both hypo-eutectic and hyper-eutectic irons. The effect of silicon content is less clearly defined, owing to less evidence being available, but it seems probable that increasing the silicon content tends to increase porosity. Phosphorus has, under all circumstances, been found to be associated with an increase in porosity.

(*b*) Inoculation, melting in contact with coke, and coarse graphite structures are associated with a decrease in soundness regardless of composition. Conversely, superheating and graphite refining treatments increase the soundness of castings. This factor may be of wider importance than is generally appreciated since the melting and metal-handling processes may well have a considerable effect upon the soundness of castings of similar composition, and suggests that in the study of soundness problems more consideration should be given to variables not connected with composition.

(*c*) Design of castings has an important effect upon soundness. This effect is so marked that other variables may produce one effect in one casting and the opposite effect in another. In any case, it is well known that altering the composition of metal affects the quality of different castings to different extents. This variable does not seem to have received much attention, possibly because it may appear to be a very complex one to investigate, but it is the belief of the Authors that if the problem of soundness is to be understood, then design factors must be studied fully. This can be done by performing experiments designed to assess the effects of variables using a number of test-pieces of different sizes and shapes, and also by studying actual castings in the foundry by statistical techniques.

(*d*) Increasing the pouring temperature of K-bar castings increases the internal porosity and decreases the surface shrinkage. High pouring-temperature favours the occurrence of deep surface shrinkage defects. The behaviour of other castings has not been reported in detail.

(*e*) Although it has received no attention in this Paper, the rigidity of the mould plays a part in determining the soundness of castings. A more-rigid mould will lead to the production of sounder castings and hence dry-sand, CO_2 Process, and hard-rammed moulds may be expected to give castings having less porosity than those made in other types of mould.

(*f*) It follows immediately from the foregoing that no single variable can be investigated to provide a guide to the soundness or otherwise of a given casting or group of castings. The important factor is clearly the mechanism by which each individual casting solidifies, both on a microscopic and a macroscopic scale, and this is governed jointly by a number of factors of which the above are, in all probability, only an important few.

In the foundry, nothing is constant, and all the conditions vary continuously, albeit sometimes only by small amounts. In the best-controlled foundries, the amount by which variables change may be small, but nevertheless they *all* change. The cumulative effects of small changes in many variables would be impossible to predict, but herein probably lies the origin of the puzzling defects which come and go without any real cause or cure being found.

Practical Applications

Investigators usually justify research of a fundamental character by stating that it will be useful in the long run. This argument does not always impress interested industrialists. It is useful, therefore, to ask to what extent the industry appears to have benefited by published work on soundness of iron castings to date. The answer certainly appears to be disappointing in view of the amount of work which has been done by investigators.

The Authors make no apology for having introduced experiments and comment on a fundamental aspect into this Paper, but it has been their aim to blend this with a liberal number of observations of the effects of foundry variables upon a number of castings. This latter kind of research is rewarding, but the investigators believe that such a field of experimentation is still too narrow and to confine

experiments to this field would show failure to recognize the true character of the problem to which attention is being given, since no laboratory casting adequately represents some other casting which is in production, and the results obtained in the laboratory can rarely be transposed into a foundry for specific application.

The Authors are currently carrying out a number of investigations in foundries where the shrinkage problems are particularly pressing or interesting. Since it is impossible in such instances to study the influence of individual factors without upsetting production, recourse is being made to well-established statistical methods for the appraisal of results. Any information so obtained about the effects of foundry variables on the amount of castings scrapped because of shrinkage defects is immediately applicable to specific problems. This line of attack may well be the most satisfactory method of assisting industry, and although in itself it does not explain the cause of shrinkage defects, its results can suggest efficient programmes of laboratory work designed to provide more fundamental knowledge.

Acknowledgment

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Transport Loss Now £70,000,000

A deficit of £30,600,000, by far the largest loss in the eight years since nationalization, was recorded last year by the British Transport Commission. The annual report and accounts of the commission show that by the end of 1955 the accumulated deficit had risen to £70,000,000, and a further substantial deficit in, 1956 is stated to be inevitable. Sir Brian Robertson, chairman of the commission, says that although he had forecast an inescapable deficit at the end of 1955, and had spoken of a determination to return to a state of balance in 1956, in the event, and because of continued inflation, this had proved much too difficult. The accounts show that the working surplus for the year was £29,500,000, but with central charges—mainly for finance—adding up to more than £60,000,000, there was a final deficit of over £30,000,000.

The report and accounts show that the partial strike of locomotive men in June, 1955, which lasted 17 days, caused a net loss of about £12,000,000. The main cause of the accumulated deficit of £70,000,000 is given as the persistence of inflation.

Because its prices are closely controlled, the commission states, the revenue it has lost through delays of one kind and another in recouping increases in wage rates and price levels now amounts to over £100,000,000, which is well in excess of the accumulated deficit. Another factor in the deficit has been the control over capital investment.

Referring to freight carryings, the BTC report says that they continued to decline last year "despite the increase in industrial production and in the volume of imports and exports." A rise in ton-miles of mineral traffic by rail was more than offset by falls in merchandise, livestock, and coal.

Railway wagons last year were replaced at a faster rate than in any previous year. Altogether, in 1955 the commission spent over the whole undertaking some £72,000,000, against £66,000,000 on new evhicles, plant, and equipment, and about £9,000,000, against £10,000,000, on additions and improvements.

Metal Box Expansion

Exports of the Metal Box Company, Limited, showed a further expansion in the year ended March 31, last, and exceeded £3,500,000, compared with £3,000,000 in the preceding year. In addition, the company supplied containers to a value of almost £5,000,000 to home customers for export business.

The holding company's commitments for capital expenditure are approximately £5,200,000, the bulk of which will be spent this year but will not become fully profit earning during the year, says the chairman, Sir Robert Barlow. Subsidiaries' commitments are approximately £500,000. The new factory at Westhoughton (Lancs) came into operation in April last, and initial installation of plant will take place during the summer at the new Carlisle works. Work commenced in March on a factory at Rochester and future extensions have proved necessary at Wisbech.

It will be difficult to maintain the percentage of profit, Sir Robert adds, but it is hoped that increased volume will offset lower profit ratios. Group income from sales and investments increased by £8,600,000 to £61,200,000 during the year under review. Dividend on ordinary stock is 10 per cent., compared with 20 per cent., but is payable on the capital doubled by a scrip issue and on 2,349,907 new shares issued during the year at £2 per share.

HICK, HARGREAVES & COMPANY, LIMITED, engineers and ironfounders, of Bolton (Lancs)—The board recommends a final dividend of 10 per cent. and bonus of 3½ per cent. for the year to March 31, 1956, on capital increased to £756,000 by a one-for-two scrip issue. An interim of 5 per cent. was paid before the issue (same). A final of 15 per cent. and bonus of 5 per cent. were paid for 1954-55 on the old capital. The total on the present capital is equivalent to 16 per cent., against 16¾ per cent. equivalent. After tax of £284,129 (£265,054), the net profit has increased from £254,468 to £289,579.

Steel-scrap Trade "Spivs"

Complaining that the decision to increase steel scrap prices by 24 per cent. on May 4, which was taken at Cabinet level, leaked out to people engaged in the scrap steel trade a week before, Mr. R. E. Winterbottom (Lab.) said in the House of Commons, that as a result scrap was withheld from the furnaces until the price rise was effective. It was profitable to the merchants to the extent that they made £100,000. There were people in the trade who could only be described as "spivs," who tried to take advantage of the market.

Everyone in the trade who had a sense of responsibility was opposed to the increase, considering it unnecessary. It had raised the price of steel on the black market and it had not produced one extra ounce for the furnaces. Moreover, it had an inflationary effect at a time when the Government was appealing for prices to be stabilized and was contributing to our exports being priced out of the markets.

Mr. A. R. W. Low, Minister of State, Board of Trade, said that scrap and pig-iron were substantially interchangeable as raw materials for steelmaking and foundry work. If the price of scrap was kept artificially too cheap steel furnaces and foundries would prefer to use scrap rather than pig-iron. This would reduce the market for pig-iron and discourage the expansion of blast furnaces which was essential to the proper expansion of steel production. For 17 years the steel industry had kept a balance between the relationship of the effective price of pig-iron and scrap, but the inevitable result of keeping scrap too low would be an increased demand for it from the foundries.

The United Kingdom was short of scrap and if we wanted to use more it had to be imported at considerable cost, and the Government felt that it ought to maintain a proper relationship between the two prices. The £2 increase had resulted in a 14s. increase in the overall price of steel, but he emphasized that this did not mean the same amount of increase to the steel user. Some parts of the engineering industry might gain by the increase in the price of scrap.

It had not been found possible to trace the source of the leak and he strongly deprecated the breach of confidence. It had been made clear to those concerned that when increases were contemplated there should be no leaks, even if consultation had to be limited.

Equipment for Automation

In an effort to capture world markets for automation equipment, Sentinel (Shrewsbury), Limited, is to increase its staff from 1,800 to between 3,000 and 4,000 within the next 10 years. This information was given by Mr. J. T. Rymer, managing director of the company, on the occasion of a visit to the Shrewsbury works by members of the Russian trade delegation. Mr. Rymer said that the works could produce between £4,000,000 and £6,000,000 worth of machinery each year. Delivery took only six weeks.

The leader of the Russian delegation, Mr. D. G. Beletsky, director of the USSR Institute of Technology, said that Russia's ability to turn out automation equipment was exceeded by the demand. Whether orders would come to British firms depended on whether it was decided to switch from hydraulic to the electro-mechanical machinery such as Sentinel was producing.

APPROVAL has been given by Wallsend Corporation to plans by M. W. Swinburne & Sons, Limited, brassfounders, for factory extensions in Hadrian Road.

Physiotherapy in Industry

Time off for hospital treatment may seem to be only a minor cause of lost man-hours in industry, but it is a natural consequence of injury and sickness. Such is the demand for physiotherapy treatment at hospitals, for example, that waiting is a necessary evil of attendance. To overcome this, many firms have set up their own physiotherapy departments and achieved a considerable saving of man-hours. The extent and possibilities of this practice form the subject of a survey which has been carried out by Aims of Industry, Limited.

The organization has published the results in a pamphlet, *Physiotherapy in Industry*, which has been circulated to a wide range of industry. The digest of statistics which is included in the pamphlet may not appeal to those with a dislike for figures, but there can be no gainsaying the Minister of Labour's recent announcement that last year 280,000,000 man-days were lost through sickness and that at any given time 1,000,000 workers were absent from work. Add to this the fact that rheumatism and arthritis—probably constituting one half of the cases treated by physiotherapy—are the commonest of all industrial complaints and it would appear that there is a great deal to be gained from the installation of on-the-spot physiotherapy units.

The sample of firms selected by the survey includes engineers, steelmakers, aircraft builders, textile manufacturers, and so on. The number of employees totalled about 93,000, 86,340 treatments were given, and the estimated total of man-hours saved was 213,480. At one steelworks employing 589 people two physiotherapists gave 415 treatments and a saving of 5,380 man-hours was effected. At a larger one—employing 10,000—one therapist gave 10,690 treatments and the saving was described as "considerable."

London Aluminium Meeting

An extra-ordinary meeting of the London Aluminium Company, Limited, has been requisitioned for July 27 by the Midland Aluminium Company, Limited, and by another shareholder to appoint Mr. J. A. Orme to the board. The Midland Aluminium Company owns one half of the ordinary capital of London Aluminium.

In a circular issued to shareholders, the London Aluminium board, with half the directors dissenting, say that it is understood that Midland Aluminium has been negotiating to sell its holding. Now it is attempting to secure control of the London board, a "position which was never intended nor would have been agreed to when an option to subscribe for the shares was granted." Midland Aluminium, it is stated, by voting in one block "is in a position to impose its will as to the constitution of the board." Shareholders who favour an independent board are asked to vote against the proposed appointment.

Simon-Carves Coke Ovens for Margam

Details are announced of the contracts, amounting to about £4,500,000, by Simon-Carves, Limited, from the Steel Company of Wales, Limited, for new coke oven construction in connection with the £48,000,000 development programme at the Margam steelworks.

Under these contracts two existing batteries of 90 coke ovens will each be extended by the addition of 25 new ovens. A complete new battery of 80 ovens, with by-product plant and coal- and coke-handling equipment, will be built on a new adjacent site.

Investigation of the CO_2 Process—Factors Influencing Compressive Strength*

By R. Ziegler and G. Hammer

Early experience with the CO_2 Process showed that under apparently similar conditions quite inconsistent results were sometimes obtained. In order to find the causes influencing the properties of CO_2-sand mixtures, several series of experiments were carried out, using three different sands and three different binders as marketed by different suppliers. The results are reported in what follows.

The aim of this investigation into the CO_2 Process was to establish the relationship between compressive strength and such factors as mixing time, binder content, CO_2-quantity used, degree of ramming of the sand, storage time of a sand mixture, standing time of hardened test-pieces and exposure to heat of hardened cores. In addition, the gas permeability and the gas evolution in contact with liquid iron were examined.

Methods

The sand mixes were prepared by mixing dried silica sand with additions of 1 per cent. coal-dust and 4 per cent. CO_2-binder in a laboratory mixer. The sands used had the following percentage sieve analysis and classification:

	Sand A.	Sand B.	Sand C.
Mesh 30	0.1	4.8	18.8
Mesh 44	2.5	22.6	29.8
Mesh 60	30.2	36.3	28.1
Mesh 100	41.7	20.8	14.8
Mesh 120	18.6	9.5	5.3
Mesh 170	3.0	2.1	1.3
Mesh 240	0.8	0.5	0.3
Mesh 300	1.0	1.0	0.3
Silt and clay	1.5	2.4	1.2
Grain fineness number ..	74	60	50
Grain shape	Rounded corners	Rounded corners	Round

Test-pieces were made by using the standard rammer. The standard cores, obtained by three rams, were hardened with CO_2 while still in the ramming tube, then pushed out and tested. All values given in this report are the average values of three estimations.

The first experiments were made by blowing CO_2 directly from the cylinder, setting the reducing valve to a standard pressure and gassing for a predetermined time. However, the values obtained by this method were widely dispersed and not comparable, because small variations of the CO_2 pressure and varying permeability of the small test-pieces considerably altered the CO_2 quantity applied. A special arrangement had therefore to be devised in order to measure the actual CO_2 quantity instead of the gassing time. The results obtained with this method showed very small dispersion of values and could be regarded as acceptable for the purpose of this investigation.

In order to establish the theoretical quantity of CO_2 required for each type of commercial binder used, 1 gm of each binder was titrated with 2 N sulphuric acid (the end-point in each case being the beginning of silica precipitation). In this way it was found that the following theoretical quantities of CO_2 were required for 100 gm binder, or culculated as a 4 per cent. addition to sand, for 100 lb. silica sand, respectively.

	g. CO_2 per 100 gm. binder (theoretical quantity).	lb. CO_2 per 100 lb. sand (eight times theoretical quantity).
Binder I ..	8.3 gm.	2.6 lb.
Binder II ..	6.3 gm.	2.0 lb.
Binder III ..	6.5 gm.	2.1 lb.

With the exception of the experiments (Fig. 3) which relate to the influence of the CO_2 quantity as

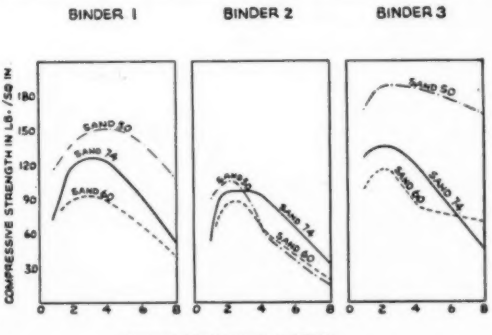


FIG. 1.—*Compressive strength of CO_2 Process sand in relation to mixing time. (Sand with 4 per cent. binder gassed with eight times the theoretical quantity of CO_2, viz. binder* (1) 2.6 *lb., binder* (2) 2.0 *lb., and binder* (3) 2.1 *lb. per* 100 *lb. of sand.)*

multiples of the theoretical quantity, generally eight times the theoretical CO_2 quantity was applied for all experiments as summarized in Figs. 1, 2, 4 and 5.

Results

A. Influence of Mixing Time

The results, shown in Fig. 1, demonstrate the decisive influence of the mixing time on the strength

* Communication from the Austrian Foundry Research Institute, Loeben; abstracted by Dr. O. P. Einerl from *Giesserei-Nachrichten* of the *Verein Osterreichischer Giessereifachleute*, May, 1955.

Investigation of the CO_2 Process

of the test-pieces. Maximum compressive strength is usually found at between two and four minutes mixing time, but variable results with other sands range from one to eight minutes. Thus it can be regarded as essential, when applying the CO_2 Process in the foundry, to determine the most favourable mixing time for the sand used under the working conditions existing.

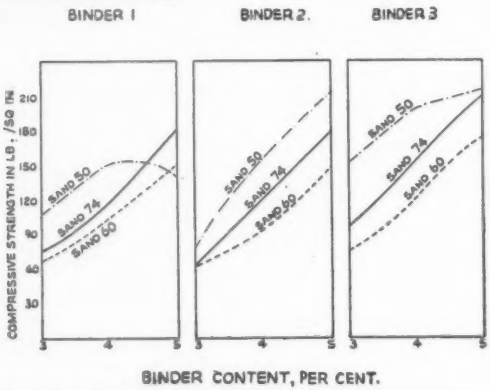


FIG. 2.—*Compressive strength in relation to CO_2 binder content for sand with 3 to 5 per cent. binder using optimum mixing times derived from Fig. 1—and the same quantities of CO_2.*

Taking the most favourable mixing times from Fig. 1, all further experiments were carried out using the following standard mixing times:

	Binder 1.	Binder 2.	Binder 3.
Sand A (grain fineness 74)	4 min.	3½ min.	2½ min.
Sand B (grain fineness 60)	2½ min.	2 min.	2 min.
Sand C (grain fineness 50)	3 min.	2½ min.	3 min.

B. Influence of Binder Content

The results, given in Fig. 2, show the general increase of compressive strength with increasing binder content, but exceptions are possible as in the case of the mixture of sand (C) (sand 50) with binder I, in which case the strength was found to decrease when the binder content exceeded 4 per cent., it similarly decreased when the CO_2 quantity applied was only double or treble the theoretically necessary CO_2 quantity.

C. Influence of CO_2 Quantity

The test-pieces were gassed with increasing quantities of CO_2, starting with the theoretical quantities and stepping up to multiples of these, up to eight times the theoretical CO_2 amounts, which latter figures were the standard quantities used in all other experiments. The results, given in Fig. 3, show generally the increase of compressive strength with increasing CO_2 quantities, but some of the mixtures proved to be nearly independent of the CO_2 quantity if at least double the theoretical amount was used. This behaviour is of great importance to the foundry because it will ensure that the gassed core or mould will have nearly the same strength at various places even if the CO_2 penetration varied widely from one end to the other, provided a minimum CO_2 quantity had access to even remote places. Looking at Fig. 3 one will notice that sand mixtures with a binder of type 2 would be much more economical in use together with sands such

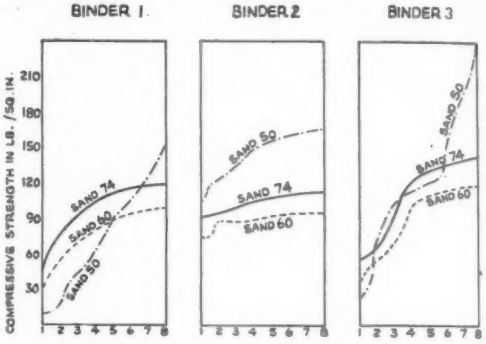


FIG. 3.—*Strength in relation to CO_2 quantity used for hardening.*

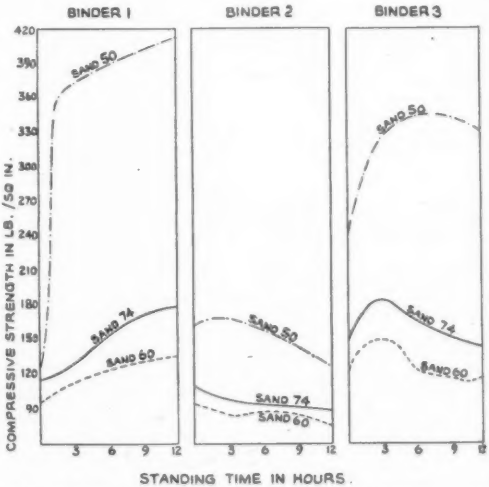


FIG. 4.—*Compressive strength as affected by standing time of test-pieces after hardening.*

as those used for the experiments because much less CO_2 would be required to obtain the same strength which other sand mixtures only achieve by using higher multiples of the theoretical CO_2 quantity.

D. Degree of Ramming

No special results were found except that the compressive strength increased linearly approximately with the number of rams.

E. Influence of Storage Time of Mixed Sand Prior to Gassing

Sand mixtures with 4 per cent. binder were covered with damp paper and left to stand. Standard cores were made after three, six and 12 hours respectively, gassed with eight times the theoretical CO_2 quantity and tested. No essential change could be observed within the first 12 hours of storage.

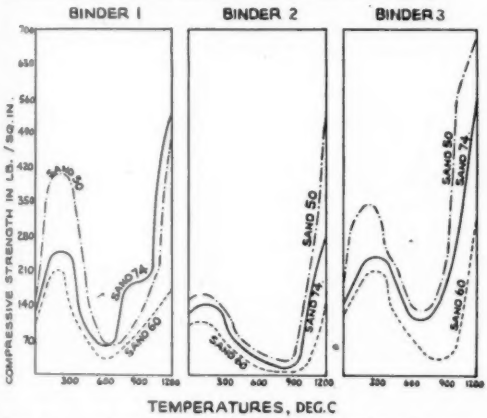


FIG. 5.—*Influence of heat on CO_2-hardened cores.*

F. Influence of Standing Time on Hardened Cores

A number of cores containing 4 per cent binder and gassed with eight times the theoretical CO_2 quantity were left to stand and strength tests were carried out after three, six and 12 hours respectively. The results are given in Fig. 4. By using binder 1, the strength increased steadily with the finer sands A and B, but with the coarser sand C (sand 50) the strength increased rapidly. Binder 2 was little influenced by standing time, whereas sand mixtures using binder 3 showed a strength maximum between three and six hours standing time. After this time, the strength slightly decreased similarly to sand mixtures with binder 2.

G. Permeability

Sand mixtures with 3 to 5 per cent. binder content were tested after three, six, nine and 12 rams respectively. Although permeability decreased with increasing number of rams, there was no indication of a different behaviour of the three binders used, neither was the permeability affected by the variations of the binder content within the experimental limits quoted.

H. Knock-out Properties at Elevated Temperatures

Test cores containing 4 per cent. binder and gassed with eight times the theoretical CO_2 quantity were subjected to temperatures from 200 to 1,200 deg. C. in a muffle furnace in order to simulate conditions existing after casting. The experimental procedure was as follows: Cores destined for testing after having been treated at 600 deg. C. were put into the furnace when its temperature was 200 deg. C. The temperature of the muffle furnace was then raised to 600 deg. C., which was held for one hour and the core was removed after the furnace had cooled again to 200 deg. C. Cores destined for testing after treatment at 1,200 deg. C. were similarly put into a preheated muffle furnace but the starting as well as the end temperatures were in this case 400 deg. C. Again the furnace was kept for one hour at the required temperature, between 600 and 1,200 deg. C.

The results, shown in Fig. 5, demonstrate that the strength generally increases up to about 200 deg. C. and then falls to very low values between 600 and 700 deg. C. (the casting temperature of the light metals). When the temperature goes up to about 1,200 deg. C. (about that of iron casting) the compressive strength again increases to reach about double the value at 200 deg. C. When the temperature goes up to over 1,500 deg. C. (the casting temperature of steel) a considerable reduction of the compressive strength takes place again.

Interpretation

It is surmised that the increase of strength at temperatures up to 200 deg. C. is connected with the loss of chemically-combined water. The decrease between 200 and 600 deg. C. can be explained as the consequence of the embrittlement of the crystal lattice of the silica, as silica undergoes a transformation within these temperature limits. The increase in strength taking place at temperatures above 800 deg. C. can be explained in connection with the beginning of a sintering process, when sodium carbonate and sodium oxide produced by the hardening process may act as fluxes.

Although the compressive strength alone cannot be regarded as the only yardstick for the knock-out properties of CO_2 cores, the experiments carried out clearly indicate that cores would be the easier to remove if the hardened sand was subjected to a temperature, during and after pouring, which reduces the strength of the sand to a minimum. Choosing a sand for a particular metal, consideration should therefore be given to the knock-out properties which will be the better the wider the temperature interval of low-strength and the lower the compression-strength itself is in the interval.

Clothes Lockers

After consultation with the trade, the Commissioners of Customs and Excise have reviewed the scope of the exemption for certain clothes lockers under Group 11(g) of the purchase tax schedule and have decided that in future it will include lockers of the materials specified, not exceeding 24 in. wide, of the following descriptions:—Lockers equipped for hanging clothes, boot lockers and combinations of clothes lockers and boot lockers, whether sold singly or in tiers or in nests. As hitherto, the exemption does not extend to wardrobes, shelved cupboards, or combinations of lockers with shelved cupboards.

Notes from the Branches

South Africa

The 20th annual general meeting and dinner of the South African branch of the Institute of British Foundrymen, was held in the Victoria Hotel, Johannesburg, on June 22. It was attended by 160 members and guests. Mr. John de Kiewet, the retiring president, presented the branch Council report for the session, in which he stated there was a net increase of 14 in the membership for the past year. At the general meetings of the branch, 10 technical papers, a problems evening, and a travelogue had been arranged; four works visits had also been included—to a soap factory, steel-pipe manufacturing company, the National Physical Laboratories and the South African Coal, Oil & Gas Corporation, Limited. Mr. de Kiewet announced that the Council had agreed to proceed with arrangements for the establishment of a Sand Research Fellowship, and that all foundries, suppliers of equipment and large users of castings, were to be approached for the necessary financial support.

Branch Awards

Mr. S. Pienaar, senior vice-president, presented the branch awards for 1956/57 to Mr. J. G. H. Loubser, who received a non-member's diploma for his paper entitled "Production Moulding of Cast-steel Bogie Components as Applied in the South African Railways," and to Mr. J. Steele who was awarded a member's diploma for his paper on the "Lost-wax" process. The Oliver Stubbs medal, which had arrived in time after having been flown over from the annual conference of the Institute in Cardiff, was then presented to Mr. John Steele by Mr. de Kiewet.

Branch officers elected for the year 1956/57 were as follow: as president, Mr. G. F. Alexander; as senior vice-president, Mr. S. Pienaar; as junior vice-president, Mr. K. H. Coombs; as hon. treasurer, Mr. S. Jane, and as secretary, Mr. J. Steele. Appointments to the branch Council include those of Mr. H. Hughes and Mr. L. Hankart, who were re-elected for a further term of office, and three new members, Mr. D. Gordon Jones, Mr. R. T. Rounce and Mr. A. F. Kukla.

In his valedictory address, Mr. de Kiewet discussed automation in relation to the foundry industry, and stated that its introduction would call, more than ever, for the specialized knowledge of the skilled craftsman to ensure maximum efficiency. At the conclusion of his speech he introduced Mr. G. F. Alexander, the new president, who then presented his inaugural address. After discussing the current position of the branch and the importance of craftsmanship, Mr. Alexander continued as follows: "I come now to a matter very near to my heart; the proposal to establish a Foundry Sands Research Fellowship of the Council for Scientific and Industrial Research. Some 10 years ago, your branch Council endeavoured to sponsor research into the availability and characteristics of the moulding sands of the Union, since, although some very fine moulding sands exist here, very little is generally known of the extent of the deposits, of their individual characteristics, or of their basic mineralogical composition. Unfortunately, it was not possible to persuade the 'powers-that-be' that the subject merited their support, so the project fell through. Recently, our Foundry Sands sub-committee has succeeded in interesting the Council for Scientific and Industrial Research in this project, which the Council has come to agree is of national importance. CSIR have agreed that if we can find sponsors within the industry to put up £1,750 per annum for three years (all amounts so subscribed to be free of income or company tax) to defray the salary and travelling expenses of a university graduate whom CSIR would appoint to the Fellowship, the Council will supply from their own funds, laboratory facilities and scientific equipment and, in addition, furnaces to provide liquid metal for casting into moulds made from materials being tested. The estimated cost of this equipment is £10,000. In spite of the multiplicity of the new processes which have come into vogue in the foundry in recent times, sand still remains the basic moulding material. It cannot be gainsaid that it will be of immense and lasting benefit to the industry if fundamental research can be undertaken into the nature and availability of South African foundry sands in an atmosphere removed from the restraints imposed by commercial competition."

A Few Statistics

Mr. W. S. Isaac, president of the Institute of Certificated Engineers, gave the following interesting facts: The combined weight of ferrous and non-ferrous castings provided by South African foundries for the gold mines was 36,000 tons per annum, representing £3,000,000 in value. From this figure, it was assessed that it required 1 lb. of casting per ton of gold-bearing rock crushed to produce $\frac{1}{10}$ oz. of gold which had a value of £2. The coal mines purchased £140,000 worth of castings, which was a tonnage of 1,500 per annum, and on this basis the coal mines used 1 lb. castings per 1 ton of coal with a pithead value of about £6. Covering coke production, Mr. Isaac stated that South Africa was faced with a serious shortage of coking coal and, according to reliable estimates, there was sufficient for only a further 50 years, as nowadays 1½ million tons of coke were being produced annually.

Dr. van Niekerk, chief research officer of the National Physical Laboratories, assured the branch of wholehearted support from his department when the Sand Research Fellowship was established, and two past-presidents of the branch, Mr. D. Lion-Cachet and Mr. J. Tonge (hon. member), addressed the meeting in lighter vein.

Changes of Name

Among the companies which have recently changed their names are those listed below. The new titles are given in parentheses.

W. H. Barnes, Limited, Victoria Street, London, S.W.1 (Steel Scaffolding Holdings, Limited).

Copelaw Engineering Company, Limited, Mowden Hall, Darlington (Copelaw, Limited).

Burnley Engineering Company, Limited, King Edward Mills, Guy Street, Burnley (Alright Products, Limited).

Decel Engineers, Limited, Prince Consort Road, Hebburn-on-Tyne (White's of Hebburn (Engineers), Limited).

Bymatic Engineering, Limited, Rivet Works, Eyesham Road, Astwood Bank, near Redditch, Worcs (Moparmatic, Limited).

Skinners (Redbridge), Limited, light precision engineers, etc., of Coniston Road, Redbridge, Southampton (Skinners (Southampton), Limited).

Recent Wills

Mackenzie, J. G., founder of the Broadway (Bristol) Engineering Company, Limited	£32,890
Paget, F. C., chairman and managing director of C. Isler & Company, Limited, artesian well engineers, of London, S.E.1	£56,715
Hughman, Sir Montague, a director and former chairman of W. T. Henley's Telegraph Works Company, Limited	£71,000
Rau, F. S., a director of Brimsdown Chemical Works, Limited, Derby & Company (Metals & Minerals), Inc., and other companies	£139,806

Society of Chemical Industry

Seventy-fifth Annual Meeting

This year's annual meeting (held from July 9 to 14) was given special emphasis to mark the Society of Chemical Industry's 75th anniversary. The lectures were on the theme "Achievements of Industrial Chemistry" and speakers reviewed the advances made during the last 25 years in the application of science to chemical plant, processes and products.

After an introductory lecture on "Modern Methods of Research" by Dr. L. A. Jordan, there were two parallel series each of four lectures—one on the new products of industrial chemistry including plastics, artificial fibres and antibiotics, and the other surveying the tools of industrial chemistry, including the use of metals and non-metals in plant construction as well as new manufacturing techniques and modern methods of recording and analysing the results of factory operations. The meeting was attended by nearly 1,000.

"Metals as Plant Construction Materials"

A paper by DR. N. P. INGLIS, M.I.CHEM.E., F.I.M., under the above title, described some of the more recent advances in metals of use as materials of chemical plant construction and new methods of fabricating these metals into the shapes and parts required by the chemical industry. In the field of chromium/nickel austenitic steels, reference was made to the relative merits of titanium and niobium as carbide-stabilizing elements and the tendency for US practice to change to the British practice of using titanium rather than niobium. The superiority of the niobium addition in the special case of resistance to concentrated nitric acid was mentioned, but recently-published work suggests that by suitable modification of the carbon and titanium contents the titanium-stabilized steel can be made equally satisfactory in this case. The development of the extra-low-carbon chromium/nickel austenitic steels was also mentioned, but the paper suggested that its value to chemical industry might not be as widespread as at first thought. The addition of other elements, particularly molybdenum and copper, to improve the range of corrodents to which these steels were resistant was discussed, together with some of the metallurgical problems to which such additions gave rise. Work in progress to develop a corrosion-resistant steel of much higher strength than previously, was referred to, and its possible interest to the chemical industry briefly discussed. Note was taken of the present serious nickel shortage and the relatively unsuccessful attempts so far to substitute manganese for some of the nickel content of this class of steel. The relatively good high-temperature strength of the chromium/nickel austenitic steels was pointed out, but developments, it was reported, mainly in connection with gas turbines and jet engines, had now made available complex steels and alloys with good creep-strength at temperatures approaching 900 deg. C. and such metals might have considerable potential for high-pressure/high-temperature plant.

In the traditional non-ferrous metals field—copper, aluminium, and their alloys—chief emphasis was on important developments which have recently taken place in methods of fabricating these metals. Argon-arc welding and inert-gas-shielded arc-welding, with consumable electrodes, were said to have greatly simplified and improved the welding of these metals and illustrations were shown of very large vessels for chemical plant made by these improved methods.

Although the very rapid development of titanium and titanium-base alloys during the past six years had been mainly sponsored by the attractiveness of this metal to the aircraft industry, its combination of high stregth and very great corrosion resistance merited careful consideration by the chemical plant designer. Its resistance to a very wide range of media was briefly mentioned, and its outstanding resistance to the most ubiquitous corrodent in chemical plant, namely water, was discussed in some detail. Test results were given for high-speed turbulent conditions, deposit-attack or shielded-area conditions, and conditions involving a combination of corrosion and erosion with sea-water as the corrodent in all cases. It was shown that of the large number of metals subjected to this series of tests, titanium was the only one which gave completely satisfactory results in *all* tests. Fatigue and corrosion-fatigue data were quoted which show that titanium was completely immune to corrosion-fatigue effects in sea-water—a result not found for any other of the large number of metals similarly tested. Attention was drawn to the relatively high price of the metal, but circumstances were discussed where its use could be economically justified.

Manufacturing Techniques

A paper on "Manufacturing Techniques" by MR. W. D'LENY, M.A., gave some interesting statistics of production by electrolytic processes. It was reported that world production of aluminium leapt from about 260,000 tons in 1930 to 3,150,000 tons in 1955; similarly, the world production of chlorine, which in 1930 amounted to approximately 500,000 tons, had increased to over ten times this figure in 1955. Of the other elements now separated by electrolytic processes, the most notable was sodium, the production of which had increased over the past 25 years from between 18,000 and 20,000 tons in 1930 to an estimated figure of 150,000 tons in 1955. The stimulus to the expansion of this metal had been provided almost exclusively by the great development in the use of lead tetra-ethyl as an anti-knock addition to petrol. The chief change of note in the technique of production of sodium was the displacement of the Castner process employing the electrolysis of caustic soda by the Downs-cell process in which the electrolyte was a mixture of fused calcium and sodium chloride. Magnesium was made preponderantly, but not wholly, by electrolysis and its output had increased from a little over 2,000 tons in 1930 to between 120,000 and 130,000 tons in 1955. Development of fluorine cells was slow until, in 1940, the demand for fluorine and fluorine compounds for the gaseous-diffusion process for separating uranium isotopes, forced a rapid expansion.

The most spectacular commercial development in fluorine chemistry during the past 25 years had been in the field of chloro-fluoro organic compounds, principally of methane and ethane. These compounds, virtually unknown in 1930, were made by the replacement of chlorine in chlorinated hydrocarbons by fluorine from HF in the presence of antimony pentahalide. The chlorofluoro methanes and ethanes were reported to be stable, odourless and chemically inert; finding their biggest outlet as safe refrigerants. The world production of these compounds had risen from nil in 1930 to about 60,000 tons in 1955.

Dortmund-Hörder Expansion Plans

According to "*Handelsblatt.*" Dortmund-Hörder expansion plans will cost £25,500,000 during the next four years, and will include the erection of a new blooming and slabbing mill, a medium section mill, and the rebuilding of two blast furnaces at the Hörde works.

Equipment and Supplies

Cupola-control Instrument

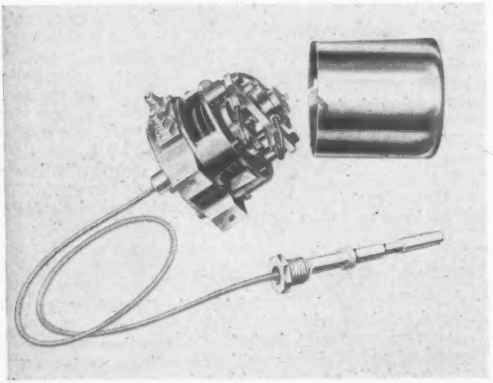
Cheltenham Auto Controls, Limited, Windsor Street, Cheltenham, Glos., have introduced a new power-amplified cupola meter—the "Cheltenham" force balance transmitter. Hitherto, blast measurement has usually been effected by observation of the differential pressure set up by an orifice disc or a pitöt tube. This differential is quite small and only minor changes are registered by large variations in volume. It therefore provides very little power to the indicating or recording mechanism. As a result, the latter is essentially of relatively delicate construction, and its useful life is thereby limited. The "Cheltenham" force-balance transmitter operates on an entirely different principle, wherein the initial differential pressure is fed to a pneumatic amplifier, the output of which is magnified about 200 times. Only a single line is required to connect the transmitter to a remote indicator or recorder, and this line may be of $\frac{3}{16}$-in. dia. copper tube, up to $\frac{1}{4}$ mile long. The indicator or recorder is an ordinary pressure instrument (operated by bellows or Bourdon tube) for a working pressure of 15 lb. per sq. in., with scale graduated in flow units. The entire equipment is robustly constructed to handle this higher pressure.

Construction

The instrument consists of two major components —the balancing unit and the input unit. The latter may be a differential-pressure element (for measuring cupola air-flow) or a static pressure element (for measuring windbelt pressure), or yet a temperature element such as that illustrated in Fig. 1. Other elements deal with liquid level, steam pressure, boiler draught, etc. Complete automatic cupola-blast control may be achieved by connecting the transmitter output to a force-balance programme controller made by this company. The controller regulates the blast in accordance with the dictation of a simple cam which can be cut out of sheet plastic or thin sheet-metal. Normally the cam is arranged to provide constant blast rate until the last charge has been added; after which the blast is gradually and smoothly reduced at a predetermined rate to any desired minimum.

Economies effected by the combination of transmitter and programme controller are reflected in decreased coke consumption and prolonged life of the cupola lining.

FIG. 1—*Force-balance transmitter developed by Cheltenham Auto Controls, Limited, Glos.*



Shotblasting Service

R. J. Richardson & Sons, Limited, of Birmingham, have formed a new company, Shotblasting (Midlands), Limited, with works at Forge Lane, Cradley Heath, Staffs, where a shotblast and shot-peening service is now in operation. The shotblast room is capable of dealing with iron and steel castings weighing up to 1 ton and 12 ft. long. In addition there is a Tilghman barrel-type Wheelabrator to deal with small castings and forgings in bulk. A 24-hour service is promised. Castings up to 10 tons in weight and up to 31 ft. long will still have to be treated at the works of the parent company at Commercial Street, Birmingham, 7.

Portable Crane Jib Extension

A new extension jib has been fitted to a standard "Staffa 2," model hydraulic portable shop crane made by Chamberlain Industries, Limited, Staffa Works, Leyton, London, E.10, supplied to the Royal Aircraft Establishment, Farnborough. The extension can be fitted in a matter of minutes to the standard jib by means of locking pins, whilst the hook and chain is simply transferred to the extension. The capacity of the equipment with extension jib ranges from 44 cwt. at an outreach of 3 ft. 6 in. and hook height of 9 ft. to 8½ cwt. at an outreach of 7 ft. 8 in. and hook height of 11 ft. 3 in.

High-energy Ignition Unit

The present trend on installations using oil-firing equipment, is to employ oils of much higher viscosity than have hitherto been used. The energy delivered by the spark of a normal ignition transformer is insufficient to ignite these heavier oils and Foster Transformers, Limited, South Wimbledon, London, S.W.19, have, therefore, developed an equipment to meet the new conditions. Two units are available, type A having an energy output of 1 Joule and type B having an energy output of 8 Joules. These have been designed to have a time rating of 5 sec. "on," 10 min. "off."

Contracts Open

The dates given are the latest on which tenders will be accepted. The addresses are those from which forms of tender may be obtained. Details of tenders with the reference ESB can be obtained from the Board of Trade Export Services Branch, Lacon House, Theobalds Road, London, W.C.1 (telephone: CHAncery 4411, ext. 738 or 771), unless otherwise stated.

ARGENTINA, August 24—Diesel-engine passenger rail cars and trailers, for the Ministerio de Transportes de la Nacion, Empresa Nacional de Transportes. (ESB/17612/56.)

EGYPT, August 14—Switchgear equipment, for the Cairo Gas and Electricty and Gas Administration. (ESB/17375/56.)

FORMOSA, August 3—Hand and machine tools, agricultural hand tools and equipment, scientific instruments, etc., for the Central Trust of China, Purchasing Department, Taiwan. (ESB/16936/56.)

INDIA, July 25—Chain hoists, elevators, and steel pipe casing, for the Government of India, India Supply Mission. (ESB/17041/56.)

SCOTLAND—Supply and erection of 132-kv switchgear at Inverarav Sub-station, Argyllshire, for the North of Scotland Hydro-Electric Board. Strain & Robertson, 5, Park Circus, Glasgow, C.3. (Deposit, £2 2s., cheque.)

SOUTH AFRICA, July 26—Workshop machines, for the Union Tender and Supplies Board. (ESB/16784/56.)

SOUTH AFRICA, July 31—Universal milling machine, for the Stores Department of the South African Railways. (ESB/16906/56.)

SOUTH AFRICA, August 7—Git cutting machines, for the Stores Department of the South African Railways. (ESB/16908/56.)

Surface Finish Comparator*

What follows is reprinted (with but minor editing) from Gray Iron News, *the house organ of the (American) Gray Iron Founders' Society. The comments recorded are therefore to some extent domestic to the American scene and should be interpreted accordingly.*

Since most of the recognized standards for castings contain specific data on only metallurgy, all other matters concerning the castings are traditionally established on an individual basis between producer and consumer. One of the most common matters of concern is surface finish. This is no small problem, since the degree of surface smoothness cannot be expressed in either words or figures. Electronic gauges which are widely used for actual measurement of smoothness on machined or ground surfaces are not suitable for use on regular casting surfaces. This difficulty has not stopped casting consumers from thinking about the problem, and one group, the (American) Aircraft Industries Association, has established a recommended standard for rating casting finish. Their "Surface Roughness Comparator," shown in Fig. 1, is a cast-aluminium block, 4¾-in. long, containing nine panels of typical casting surfaces with increasing roughness. Table I was prepared by the Aircraft Industries Association panel to give similar R.M.S (values obtained from electric surface instruments), designation for each "C" number and the approximate range for the various methods of casting. The indicated range for ferrous castings could well have been extended down to C-70 or possibly even C-60.

At the present stage of development, the use of this Comparator for purchase specifications would present considerable difficulty, since there is insufficient experience on which to base interpretation, but it can be of value in discussions with customers if it is used correctly.

It is most interesting to observe that this Comparator was developed by an organization of casting consumers, without official foundry representation. Fortunately, it is intended for use with aircraft-quality aluminium castings, but it is no less indicative of the trend towards more specifications in the ironfoundry industry, too. Unless ironfounders also are progressive in this matter, customers of the castings industry will either create their own specifications for them or look to competitive industries for their needs.

The steady trend toward more and closer casting specifications is well recognized as a part of modern industrial development. Ironfounders cannot turn their backs to customer requirements if they are to remain a progressive and competitive industry. With sound information and experience, the trend can be so guided that the specifications remain practical as they become more specific.

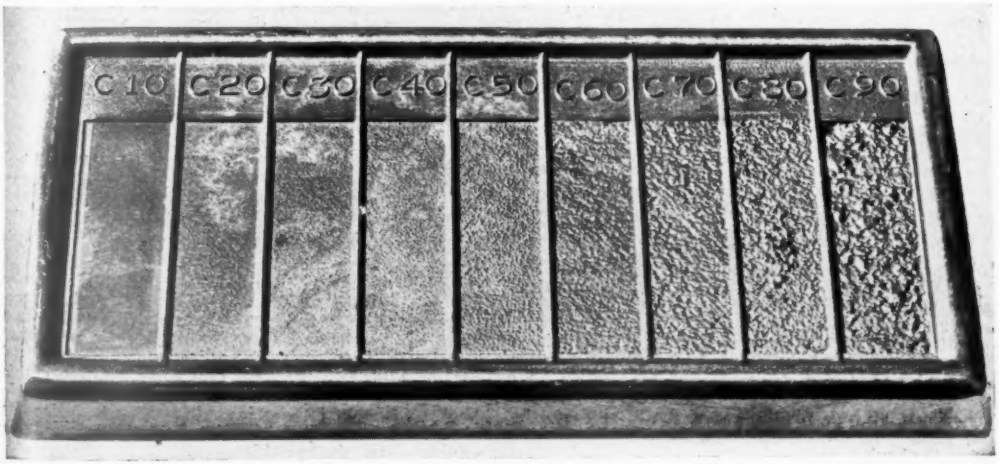
TABLE I.—*Approximate Range of Various Casting Methods in Relation to Surface Roughness (Aircraft Technical Committee of A.I.A.).*

Comparator "C" number.	Similar R.M.S†	Casting process applicable. Brackets.	Process.	Range.
C 10	20		Pressure die-casting ..	20—120
			Investment casting ..	60—120
C 20	60		Shell-mould casting ..	60—200
C 30	120		Gravity-die-casting ..	120—420
C 40	200			
C 50	300			
C 60	420			
C 70	560		Normal non-ferrous sand casting	300—560
C 80	720		Normal ferrous green-sand casting	720—900
C 90	900			

* Available, in a mahogany box, from Wheel Craft, Inc. 1,100 W. Foothill Blvd., Azuza, California, U.S.A.

† R.M.S. = Root Mean Square deviation from flat, in micro-inches.

FIG. 1.—*Cast Surface Comparator for aluminium alloys developed by the (American) Aircraft Industries Association; it is 4¾-in. long.*



Company News

ALUMINIUM CASTINGS COMPANY, LIMITED—Arrangements are being made to provide further finance through a £400,000 6 per cent. debenture issue, redeemable 1976-86. The stock is being placed privately at 97 with a quotation.

HADFIELDS, LIMITED—The board is raising its interim ordinary dividend from 3½ per cent. to 4 per cent. for the year ending September 31, 1956. This payment, and the previous year's final of 4 per cent., are on the capital as increased by the shares issued against the acquisition of Millspaugh, Limited.

B. & S. MASSEY, LIMITED, makers of steam and power hammers, dropstamping plant, etc., of Openshaw, Manchester—Future demand for the company's products shows no sign of falling off, states Mr. K. F. Massey, chairman, who adds that there is enough work on hand to keep the company occupied until 1958.

K. G. (HOLDINGS), LIMITED, electrical and mechanical engineers—The directors announce that conditional arrangements have been made to acquire the entire issue ordinary capital of a manufacturing company in the electronics field for the consideration of approximately £27,500 of ordinary capital of K. G. (Holdings).

FIRTH BROWN TOOLS, LIMITED—Deliveries effected in the year ended March 31 were a record, both by value and by volume. Business was extended both at home and abroad, but Lord Aberconway, chairman, states that export conditions have become increasingly competitive. Group stock and work in progress have expanded and the chairman says that financing of such items brings a serious problem under to-day's inflationary conditions.

GUEST, KEEN & NETTLEFOLDS, LIMITED—The company has offered to buy the issued share capital of Australian Steel Split Pulleys, Limited, Sydney. The offer is one of 24s. in Australian currency for each £1 Australian share and is the result of an approach to Guest, Keen & Nettlefolds by Steel Split Pulleys through Joseph Sankey & Sons, Limited, the GKN subsidiary. It requires acceptance by 90 per cent. of the Australian company's shareholders, of whom a meeting will be asked to ratify the offer, which expires on July 31.

TANGYES, LIMITED, diesel-engine manufacturers, etc., of Smethwick (Staffs)—A profit for 1955 of £2,720, subject to tax only, which compares with a loss of £57,514, is announced by Sir Basil R. G. Tangye, the chairman. There is a loss on the Canadian company, but there is on hand a number of important inquiries and some substantial orders so that 1956 prospects are "very much improved." Sir Basil, who visited the Sudan, Egypt, Persian Gulf, Iraq, Persia, the Lebanon, and Turkey, reports very substantial orders for pumps and oil engines for irrigation purposes.

AIRSCREW COMPANY & JICWOOD, LIMITED—Although trading profits expanded from £71,270 in the previous year to £106,255 in the year ended March 31, the directors are not recommending a dividend on the ordinary capital, whereas a total of 12½ per cent. was paid for 1954-55. Mr. J. D. Titler, chairman, states there are heavy commitments, both to the bank and as regards financing increasing turnover, and in view of credit restrictions, which are seriously affecting business, and the high rate of tax attracted by distributed profits, it has been deemed advisable not to recommend a dividend. So far it has not been possible to replace bank borrowings by further permanent capital and for the time being the company has to rely on assistance from the bank.

New Patents

(Copies of complete specifications are obtainable from the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, London, W.C.2, price 3s.)

749,813. Morris Bean & Company, Yellow Springs, Ohio, Illinois, USA.

A process of making moulds for casting. A wastable pattern is formed of a material which, initially, has sufficient rigidity to hold its form, surface character, and dimensions at room temperature under conditions of handling usual in foundry practice. This pattern is applied to a mixture of refractory granular material and a heat destructible binder adapted to cement the contacting surfaces of the refractory grains, but insufficient in amount to close the interstices between the grains. The resulting mass enclosing the wastable pattern is then subjected to conditions designed to convert it into a rigid-bonded cohesive mould. The wastable pattern is then disintegrated, the pattern material removed from the mould, and the mould surface carefully cleaned. This invention is claimed to make possible the formation of accurate smooth moulds with a permeability exceeding A.F.A. 50, even though the pattern may have undercuts (re-entrant angles) such that a normal rigid pattern could not be withdrawn as such.

749,823. Stewarts and Lloyds, Limited, 41, Oswald Street, Glasgow, C.1.

A method of controlling the final composition of the iron when prepared from its ore in a blast-furnace. At least a proportion of the charge consists of ore in the form of pellets. A proportion of the amount of pelletized ore is preheated in order to change its constituents. The preheated pellets are then added to the remainder of the charge, the whole being subjected to blast-furnace treatment. The preheating is effected (1) to vary to percentage of sulphur in an oxidizing atmosphere at a temperature of 1,175 to 1,250 deg. C. and (2) to vary the percentages of ferrous and ferric iron in the ore, at a temperature of 900 to 1,100 deg. C.

749,993. Continental Copper & Steel Industries Inc., 345, Madison Avenue, N.Y.C., N.Y., USA.

Steel for die-casting moulds which is of the non-cutting tool steel type. It is machinable after heat-treatment and is highly resistant to cracking and crazing. Its constituents are, Si up to 1, Co 12 to 30, and C 0.02 to 0.1 per cent., the remainder apart from usual impurities being iron. Additions are also claimed of Cr 2 to 6, Mo 2 to 7, Va 0.75 to 2.5, W 2 to 7 and Mn 0.2 to 0.4 per cent. The molybdenum and tungsten should be in the ratio 5 : 4.

750,012 and **750,080.** Regie Nationale des Usines Renault, 8-10, Avenue Emile Zola, Billancourt (Seine), France, and Ste. de Hauts Fourneaux et Forges d'Allevard, 12, Rue de la Rochefoucald, Paris (Seine), France.

Improvements in pressure die-casting machines, especially those for ferrous metals. **750,012.** A device for rejecting the residue at the bottom of the magazine comprises a forked rod articulated on the fixed plate of the machine. On this rod there is articulated an ejector pin emerging from the bottom of the metal magazine through the fixed part while the free end is connected to another rod articulated to the movable part of the metal magazine. **750,080.** A device for extracting the cooling core from the casting and the casting from the mould.

News in Brief

MEADOW FOUNDRY COMPANY, LIMITED, proposes extending the premises at Littleworth, Mansfield, Notts.

THE TOTAL ATTENDANCE at the International Machine Tool Exhibition, held at Olympia between June 22 and July 6, amounted to 100,089.

SHALLWAY CORPORATION, manufacturers of shell-moulding equipment, have taken space at the International Foundry Trades' Fair to be held in Düsseldorf from September 1 to 9.

JOHN SMITH (KEIGHLEY), LIMITED, crane makers, announces that its works will close on July 27 and reopen on August 13 for the summer holidays. A small staff will be available to deal with urgent matters.

THE OFFICES of the Polford Engineering Company, of Heaton Junction, Newcastle-upon-Tyne, have been transferred to its parent company, Wilson's Forge, Limited, the Engineering Works, Bishop Auckland, Co. Durham.

THE LATE MR. HENRY BUNTING, formerly works manager of the Rutland Foundry Company, Limited, a founder member, and for 20 years secretary, of the East Midlands branch of the Institute of British Foundrymen, left estate valued at £2,415 gross.

EXTENSIONS to the works of G. W. S. Burdett & Company, Limited, machine-tool makers of Peterborough, are due for completion this summer. The motor engineering department is to be brought under the same roof as the machine tool and general engineering section.

Sir PERCY H. MILLS, chairman of W. & T. AVERY, LIMITED, ironfounders and weighing-machine manufacturers, Birmingham, presented on July 14, £50 to eight employees who have each completed 50 years' service with the firm, and gold watches to 47 who have completed 40 years' service.

MANUFACTURING COMPANIES concerned in the announcement of orders worth £4,500,000 placed in this country for telecommunication equipment for Nigeria are the General Electric Company, Limited, Siemens Bros. & Company, Limited, Ericsson Telephones, Limited, and Pirelli-General Cable Works, Limited.

GEORGE ELLISON, LIMITED, Perry Barr, Birmingham, announce the appointment of Mr. L. A. Yardley as sales engineer in Lancashire, Yorkshire, Northumberland, Cumberland and Scotland. His headquarters will be the Manchester office of the company at No. 1, Central Street (telephone: Blackfriars 7637-8).

ORDERS for three large transformers, to a total value of over £200,000, have been placed with the English Electric Company, Limited, by the Tennessee Valley Authority. These bring the total of transformer contracts placed with English Electric by the TVA to four. The transformers will be built at the Stafford works of the company.

KELLY & SHIEL, LIMITED, United Works Distillery Road, Dublin, has been appointed agents in Eire for the complete range of the English Electric Company's engineering equipment manufactured at the Stafford, Bradford, and Liverpool works. Kelly & Shiel has acted as distributors for English Electric's electrical domestic equipment for the past eight years.

AN ORDER from Henry Meadows, Limited, Wolverhampton, for 200 "Square Path" alternators worth about £70,000 has been received by the Brush Electrical Engineering Company, Limited, Loughborough. The alternators will be coupled to Meadows engines for sale as generating sets to the Egyptian Government. Each alternator has an output of 26.58 kw, 220 v, at 1,000 r.p.m.

Mr. P. J. C. BOVILL, managing director of Newton Chambers & Company, Limited, engineers, Thorncliffe Works, Sheffield, has received a telegram of congratulations from Lord Mackintosh, National Savings Committee chairman, on the passing of the £1,000,000 mark in the firm's National Savings. Earlier this month Mr. Bovill presented awards to the firm's apprentices.

THE PENSIONERS' WORKSHOPS at Rotherham of Steel, Peech & Tozer, a branch of the United Steel Companies, Limited, which was opened to provide occasional labour for retired employees of the company, is to be closed because of lack of support. An approach is being made to local authorities to see if a similar place can be set up in the town centre with support from other steelworks in the area.

A NEW PLANT for the continuous production of nitroglycerine is expected to be in full operation at the Ardeer, Stevenston, works of the Nobel division of Imperial Chemical Industries, Limited, by the end of this year. The plant will be operated from a control desk in a building removed from the one containing the actual process, with staff following the process on closed circuit television chains.

AN INTERNATIONAL CONFERENCE ON FATIGUE OF METALS, sponsored by the Institution of Mechanical Engineers with the co-operation of the American Society of Mechanical Engineers, will take place in London from September 10 to 14. Follow-up meetings, arranged by the American Society of Mechanical Engineers, will be held in New York from November 28 to 30, as part of that Society's annual meeting.

THE EXTENSION to the works of Bertrams, Limited, at Sciennes, Edinburgh, manufacturers of papermaking machinery, is now complete and will eliminate a bottleneck by hastening the production of drying cylinders. The new shop is 250 ft. long and has a span of 60 ft. It is serviced by 50 and 10 ton travelling cranes. This new shop covers the site of the original building in which William Bertram started business in 1821.

BURROUGHS ADDING MACHINES, LIMITED, are to build a new group of factories for making office machinery on a 72-acre site at the new town of Cumbernauld, 16 miles north-east of Glasgow. Work on the first unit will start immediately. It is understood that the company plan to invest £10 million in their project, which will be a major addition to one of the most welcome industrial developments in Scotland since the war.

THE NORTH THAMES GAS BOARD has awarded a contract to Humphreys & Glasgow, Limited, London, S.W.1, for the installation of four refinery gas-reforming plants at Romford (Essex). The plants will be of the self-steaming type, using the Onia-Gegi catalytic conversion process. They will be erected in the open with buildings to house the controls, machinery, and boosters. The contract includes all civil engineering work and ancillary plant.

MATTHEW SWAIN, LIMITED, ironfounders, Newton Heath, Manchester, who are celebrating their 80th year in business, held their annual works outing on July 7 at Morecambe with approximately 200 employees as

News in Brief

guests for the day. After luncheon, the chairman of the company, Mr. Matthew Alec Swain, made presentations in recognition of long service; these included Mr. L. Hinchley with 55 years' service and Mr. J. T. Potts with 50 years' service.

THE FORMATION of a new company under the name of Efco-Edwards Vacuum Metallurgy, Limited, is jointly announced by Edwards High Vacuum, Limited, Manor Royal, Crawley (Sussex), and the Electric Furnace Company, Limited, Weybridge (Surrey). The first products of the new company are a range of vacuum melting and pouring furnaces designed for research and production and other standard plant for sintering, brazing, annealing, and degassing metals.

OWEN & DYSON, LIMITED, railway wheel and axle makers, Rother Iron Works, Rotherham, have secured a contract worth £478,500 for 5,000 wheels and axles for Indian Government Railways. The contract, which was secured against world competition, represents a triumph for the company because it is the first time since 1951 that British makers have been successful in securing orders from this market. The wheel and axle sets are of broad gauge with a 16-ton capacity and solid forged.

DISCUSSIONS have taken place between members of the Russian trade mission, headed by Mr. V. A. Malyshev, and the President of the Board of Trade, Mr. Peter Thorneycroft, on the purchasing programme submitted to the Government during the visit of Mr. Bulganin and Mr. Khruschev in April. Mr. Malyshev and the members of the delegation will visit, in small groups, firms in various parts of the country; full details of their programme are being worked out in consultation with the Board of Trade and industry.

WHILE OUTPUT PER HEAD in the United Kingdom is still the highest in Europe, our productivity is not yet high enough to meet the vital need to increase our exports as well as the increasing demand for consumer goods, says the British Productivity Council in a review of its work since its establishment in 1953. The clear alternative, declares the council, is either our standards of living can fall to the level warranted by our present productivity or we can raise that productivity, by the use of modern techniques, to the point where it can support our demands.

THE Richardsons Westgarth group of companies has published an illustrated booklet giving details of the group's apprenticeship schemes. The four works of Richardsons Westgarth (Hartlepool), Limited, the North Eastern Marine Engineering Company, Limited, and George Clark & North Eastern Marine (Sunderland), Limited, are engaged on the manufacture of all types of marine propelling machinery and a wide range of power plant for industrial use. There are openings for four different groups of apprentices with ages at entry ranging from 15 to 18½.

ESTABLISHED by the Engineering Industries Association, the scheme for the co-operative training of apprentices has now been launched in Birmingham and the Midlands. It is being administered by Industrial Administration (R. & A.), Limited, whose representative, Mr. B. Whittaker, is using the Birmingham Engineering Centre as his headquarters. The object of the scheme is to enable small firms to give a full training to apprentices, equal to that offered by the larger concerns. Apprentices are indentured to one firm but gain experience in other companies.

Law Cases

Foundry Moulder's £5,242 Damages

Said by Mr. Justice Lynskey to have suffered terrible injuries and serious limitations on his pleasures and recreations, and to have lost the amenities of life, Harold Frederick Hoofe, of Ardern Avenue, Dawley, was awarded £5,242 damages, with costs, at the Salop Assizes. He claimed damages from an ironfoundry firm at Dawley for injuries received when working as a moulder at the company's foundry on September 18, 1952, when a pot of molten metal fell over so that the metal was spilt on his left foot and the toes on that foot later became gangrenous and had to be amputated.

Mr. Gilbert Griffiths, opening the case for Hoofe, said special damages had been agreed at £622 7s., and it had also been agreed that there was a continuing loss of £4 a week. Hoofe had been assessed as a 30 per cent. disabled person, and had a special hardship allowance.

Giving evidence, Hoofe said he put his scoop down on the sand of the floor bed, it tipped up, and the metal ran over his foot. The ring had been cut to enable it to handle larger scoops, and he had complained about it.

Mr. Justice Lynskey said Hoofe had now a foot which he could not use efficiently. He had no correct feeling of balance on it, and it was agreed by doctors for both plaintiff and defendants that he would never be able to go back to his old work of moulding. It had been agreed that the continuing loss of earnings was £4 a week, and that apparently would continue the rest of his life.

It was not merely the loss of earning, the judge continued. Hoofe apparently had been a good athlete, and had a number of interests outside his work; those were all denied to him now. Judgment was given for £5,242, with costs for the plaintiff.

Guard Off—£1,850 Damages

"Negligence rests fairly and squarely on the shoulders of the defendants," said Mr. Justice Bryne at Sheffield Assizes on July 2, when damages for personal injuries had been claimed against a Sheffield firm of toolmakers. Charles Hogg, aged 38, made the claim as a result of losing three fingers at work in an accident. He told the court that while working at a saw-grinding machine he slipped on a duckboard and put out his right hand to save himself, and lost three fingers in the machine's unfenced bevel gears.

Mr. G. S. Waller, Q.C., for the company, said that Hogg knew it was his duty not to work the machine without a guard. The guard had frequently been taken off and put on by the plaintiff. The Judge said that Hogg had been a truthful witness. The machine had a guard but after two new motors had been fitted, he found the guard would not fit properly. He reported the matter to an engineer and after the complaint the guard remained off. Then the accident took place. He could not agree, he added, that Hogg had been guilty of contributary negligence. The machine did not have a satisfactory guard after the fitting of the motors.

The Judge went on to deal with the fact that Hogg's wages were now slightly more than his pre-accident wages, and that the firm's general manager, Mr. S. W. Haywood, had said he would still employ Hogg as a saw-grinder in the open market. But, the Judge said, in the event of a depression Hogg might find difficulty in the open labour market, and "the world isn't full of Mr. Haywoods." He awarded damages to Hogg of £1,750 plus £100 agreed special damages.

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Personal

Mr. W. B. LAWRIE, M.SC., M.B.E., now resides at 14, Park Hill Rise, Croydon, Surrey.

Mr. N. C. PEARSON has been appointed assistant managing director of Borax Consolidated, Limited, Carlisle Place, London, S.W.1.

Mr. E. J. CLARKE has retired from his appointment as chief engineer of Murex Welding Processes, Limited, Waltham Cross (Herts), after 38 years with the company.

Mr. P. E. WIGHTMAN, director of Brockmoor Foundry Company, Limited, Brierley Hill, has changed his home address to Whiddon End, Yarhampton Cross, Stourport-on-Severn, Worcs.

Mr. E. G. HARRISON, financial director and secretary of John Dale, Limited, has retired after 34 years' active association with the business. Mr. C. J. CHILD has been appointed secretary of the company.

Mr. H. W. SWEATT, chairman of the American associated company of Honeywell-Brown, Limited, visited this country to be present at the opening of the company's 80,000 sq. ft. factory in Lanarkshire.

Mr. GEORGE W. BURGER has been appointed managing director of Knowsley Cast Metal Company, Limited, Titan Works, Trafford Park, Manchester, and Mr. JAMES J. MUNDELL has been made a director.

Mr. GEORGE LITTLEWOOD, chairman and managing director of the Rood End Foundry Company, Limited, Oldbury, has been installed as president of the West Bromwich Rotary Club. He has been a member since 1944.

Col. ERIC PHILLIPS has been appointed chairman and chief executive officer of Massey-Harris-Ferguson, Limited. Col. Phillips succeeds Mr. JAMES DUNCAN, who for reasons of health has resigned as chairman, president and director.

Mr. ERNEST HINCHLEY, joint governing director and vice-chairman of Keep Bros., Limited, export merchants, of Birmingham, this month completes 65 years' continuous service with the firm with which he is still actively associated.

On his resignation as chairman of the Dengie and Maldon division bench of magistrates upon reaching the age limit, Mr. C. C. BOOTH, of Booth & Brookes, Limited, Burnham-on-Crouch, was presented by his colleagues with a barometer.

Sir HERBERT MERRETT, J.P., has resigned from the board of the Western area of the British Transport Commission. He was originally appointed chairman of the board in January, 1955, but after an accident he relinquished this office while retaining his seat on the board.

Mr. PETER B. HIGGINS, managing director of Yorkshire Engineering Supplies, Limited, of Leeds, and vice-president of the Association of Bronze and Brass Founders, has joined the board of Jonas Woodhead & Sons, Limited, of Leeds, manufacturers of springs and the like.

A.P.V.-Paramount, Limited, founders of stainless and alloy steels, announce the appointment of Mr. E. J. COOPER, B.SC., as production superintendent in succession to Mr. L. J. L. DAVIES, A.M.I.MECH.E., who has joined the company's sales staff as Southern area representative.

Mr. ALEXANDER EASTON retired recently from the Bonnybridge foundry of Smith & Wellstood, Limited, after more than 50 years' service. A native of Dumfries, he went to Bonnybridge in 1889 and in 1898, at the age of 12, entered the employment of the firm as an apprentice moulder. After war service he returned to the foundry in 1919 as a moulder and several years ago took charge of the pattern store. He was presented with a smoker's set from his colleagues.

Mr. GILBERT F. DAVIES has been appointed deputy chairman and Mr. J. ASPINALL deputy managing director of Hick Hargreaves & Company, Limited. Mr. Davies will continue to act as London director. Three special directors have been appointed in Mr. J. L. LEYLAND, secretary and commercial manager, Mr. J. J. WARBURTON, sales manager, and Mr. J. V. BARNETT, technical representative (northern division). Mr. T. NUTTALL has been appointed works manager.

Sir FREDERICK SCOPES, managing director of Stanton Ironworks Company, Limited, near Nottingham, has been appointed an Officer Brother of the St. John Ambulance Brigade. He is already a serving Brother. Mr. S. C. BOND, transport and shipping manager of the company, has been elected chairman of the National Road Transport Federation. Mr. Bond is also president and chairman of the National Council of the Traders' Road Transport Association. He was for nine years the East Midlands Divisional chairman of the TRTA.

The Lancashire Dynamo Group announce that Mr. R. V. ELY, M.I.E.E., M.I.MECH.E., has been appointed group research director by Lancashire Dynamo Holdings, Limited, and will, as a consequence, relinquish his position as managing director of Foster Transformers, Limited, and Foster Electrical Supplies, Limited. He will, however, remain on the board of both of these companies with special responsibilities. Mr. M. H. HAMMILL B.SC.(ENG.), A.M.I.MECH.E., director and general manager of Foster Transformers, Limited, will be in executive charge of the company, and Mr. L. D. GUNNELL, at present sales director of Foster Electrical Supplies, Limited, will act in a similar capacity in that company.

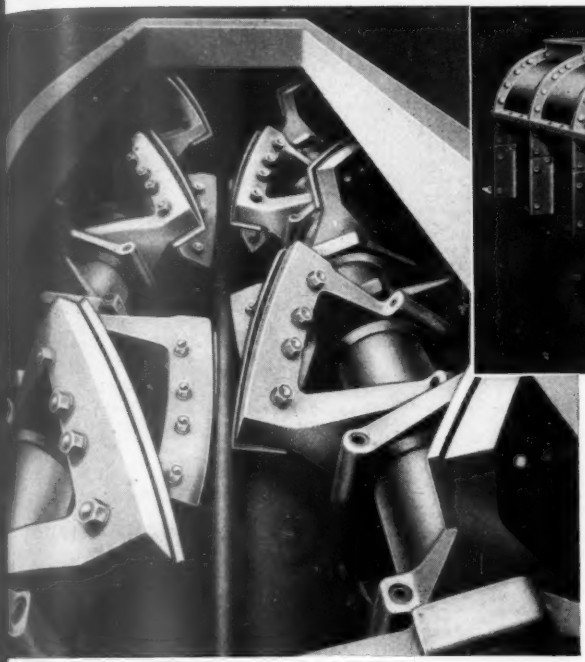
When he leaves Australia at the end of this year to take up residence in England, Mr. C. Y. KNIGHT will retire from the Associated Electrical Industries, Limited, group. He will cease to be a director and chairman of Australian Electrical Industries Pty., Limited, as from September 7, but will remain as deputy chairman of the company until his departure from Australia. Major-General Sir JACK STEVENS will join the board of the AEI group in Australia on September 7, following his retirement from the Commonwealth Public Service and the chairmanship of the Australian Atomic Energy Commission. He will succeed Lord Chandos as chairman of the holding company, AEI, and Mr. Knight as chairman and chief executive of the operating company, Australian Electrical Industries Pty.

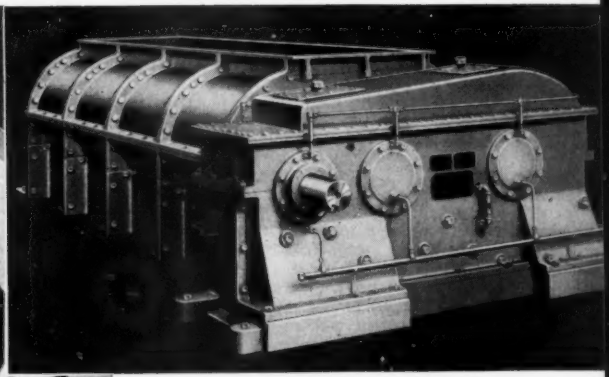
Obituary

The American Press records the death of Dr. CHARLES R. AUSTIN, assistant to Mr. OLIVER SMALLEY, the president of the Meehanite Metal Corporation, New Rochelle, N.Y. In 1945, Dr. Austin was awarded the Henry Marion Hall gold medal by the American Society for Testing Materials.

Mr. F. J. COWLIN, who was chief engineer of the steam turbine division of the English Electric Company, Limited, Rugby, died at Klagenfurt, Austria, on June 28 at the age of 65. He had been attending the World Power Conference in Vienna. Mr. Cowlin was appointed O.B.E. in this year's New Year Honours in recognition of his services to the Admiralty on a committee formed to develop improved designs of naval steam turbine propulsion machinery.

Batch and Continuous Sand Mixers





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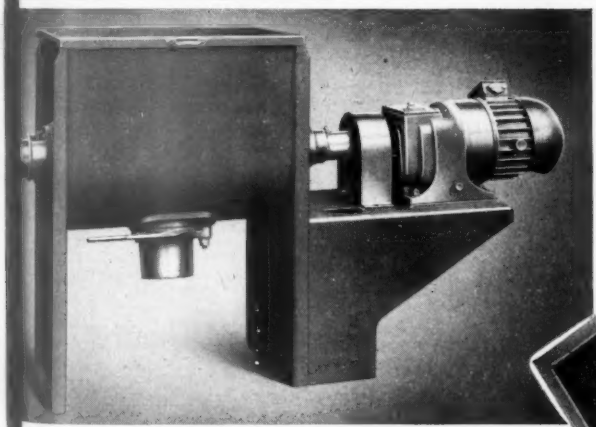
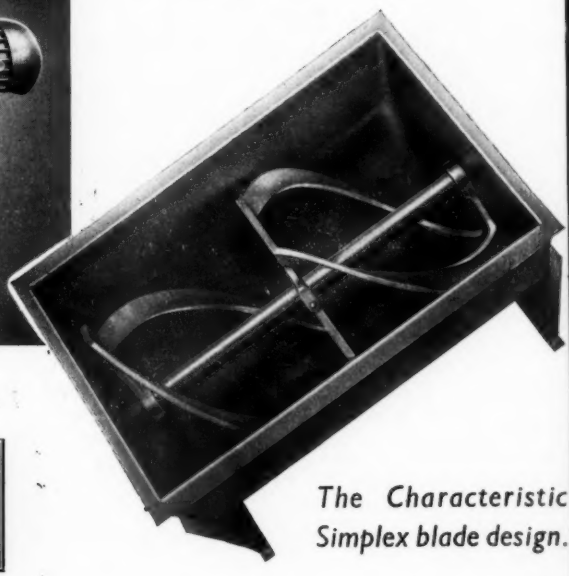


CH MIXERS Made in a variety of sizes.



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Raw Material Markets

Iron and Steel

With the exception of basic pig-iron for the steelworks, current outputs of pig-iron meet the needs of consumers more fully than for some time past. Pressure for increased supplies of basic steelmaking pig-iron is maintained, and until additional home productive capacity becomes available, regular shipments from abroad will be required. Improved outputs of hematite and low-phosphorus iron, coupled with reduced demands from some of the engineering foundries, have brought the supply of these grades more in line with current needs. Many users are able to obtain allocations to cover their work in hand, although fresh users still find difficulty in obtaining all they require. The demand for these grades from the foundries connected with the motor vehicle trades shows a steady decline and an increasing number of these foundries are on short time. Business is brisk for the makers of high-duty castings for the steelworks, collieries, and other trades, while machine-tool makers, power and electrical plant equipment makers, heavy engineering plant manufacturers, and other concerns are busy and are specifying freely for castings.

The demand for high-phosphorus iron is quiet, with the light-castings trade showing little sign of improved production. The jobbing foundries and some of the engineering foundries are taking up fair tonnages, but the light and textile foundries have only moderate demands, and with the holiday season approaching these are not likely to be stepped up in the near future. Overall outputs are generally sufficient to satisfy demands, although present productive capacity is below normal.

The re-rollers have plenty of business on hand at present and are fairly well supplied with raw materials, except for the smaller sized billets. Their outputs have been increased in recent weeks due to a slightly better labour situation. Home consumers and stockists are receiving the major portion of their output. Fresh business from home sources is plentiful, while the volume of orders for oversea buyers is restricted only by the tight supply position.

Non-ferrous Metals

Copper is an interesting market on both sides of the Atlantic. In the United States the market has been firmer for metal from Custom smelters, who raised their price by ½ cent to 38 cents a pound at the end of last week, and from dealers, who are offering copper at upwards of 37 cents. Demand from producers, whose price—despite the recent cut to 40 cents—is still the highest in the world, is small although trade circles are inclined to believe that fabricators, who have been buying very sparingly in recent months, will come to the fore in the market, but increased demand will presumabily have to await the end of the holiday period and a settlement of the US steel strike.

In London the contango in copper has disappeared and prices have been moving towards higher levels. This is surprising, considering the amount of copper there is in registered warehouses, but there might well be uneasiness engendered by labour disturbances in Rhodesia.

Dealings in tin have been inconsistent, reaching good levels at times. The labour disputes in Malaya put a bottom to the tin price, while the continuation of the US steel strike prevents the price from advancing very far. Nevertheless, supplies are not plentiful and should fate have in store a general strike in Malaya and a steel strike settlement, the resultant surge in demand would hoist the tin price spectacularly.

In the margin it should be noted that demands have been presented to the aluminium producers by the United Steelworkers' Union and contracts expire at the end of this month. The steel strike has already cast its shadow over the secondary aluminium industry and smelters are rapidly losing their market for de-oxidizing ingot, although primary producers are operating at peak levels.

The market for zinc has been poor, especially in the States, where demand from diecasters for special high-grade zinc and the business emanating from brass-mills are indifferent. In the United Kingdom sentiment is better as a result of the unsettled conditions on the Australian waterfront and the continued confidence in the American support policy, which led to the absorption of over 15,000 tons for the stockpile in June. For much the same reasons lead has been a fairly good market in London. In June over 10,000 tons were taken off for the US stockpile.

Official metal prices were as follow:—

COPPER, Standard—*Cash:* July 12, £294 10s. to £295; July 13, £290 to £291; July 16, £290 to £291; July 17, £289 to £289 10s.; July 18, £278 10s. to £279.

Three Months: July 12, £292 to £293; July 13, £288 10s. to £289; July 16, £288 to £288 10s.; July 17, £287 to £287 10s.; July 18, £277 to £277 10s.

TIN, Standard—*Cash:* July 12, £748 to £749; July 13, £746 to £747; July 16, £751 to £752; July 17, £752 to £753; July 18, £744 to £745.

Three Months: July 12, £745 to £746; July 13, £744 to £745; July 16, £747 to £748; July 17, £748 to £749; July 18, £742 to £743.

LEAD—*First half July:* July 12, £114 15s. to £115 5s.; July 13, £114 to £114 5s. *Second half July:* July 16, £114 10s. to £114 15s.; July 17, £114 to £114 5s.; July 18, £113 5s. to £113 10s.

First half October: July 12, £112 15s. to £113 5s.; July 13, £112 10s. to £112 15s. *Second half October:* July 16, £112 15s. to £113; July 17, £112 5s. to £112 10s.; July 18, £111 15s. to £112.

ZINC—*First half July:* July 12, £94 to £94 5s.; July 13, £93 5s. to £93 10s. *Second half July:* July 16, £93 15s. to £94; July 17, £93 15s. to £94; July 18, £93 5s. to £93 10s.

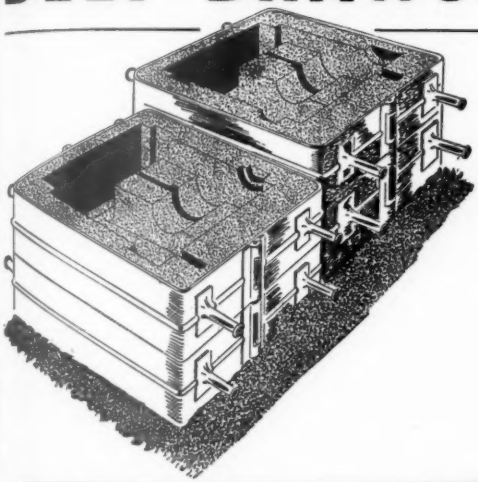
First half October: July 12, £92 10s. to £92 15s.; July 13, £92 5s. to £92 10s. *Second half October:* July 16, £92 15s. to £93; July 17, £92 10s. to £92 15s.; July 18, £92 10s. to £92 15s.

Drop in Unemployment

Between the end of February and the beginning of June short-time working on British industry increased by over 50 per cent., but there was almost no decline in the amount of overtime worked. In the period from May 14 to June 11 there was a decline of 15,000 in the number of unemployed, which by the middle of last month accounted for only 1 per cent. of the working populaton, the same as in June last year. The number of persons in civil employment rose by 20,000 during May to nearly 23,000,000, which was about 90,000 more than in May last year and 50,000 more than in March of this year.

At the end of May the number of unfilled vacancies was 397,000, compared with 223,000 unemployed (including 33,000 temporarily stopped). The vacancies figure is 16,000 more than at the beginning of May, but 47,000 less than a year ago. Labour shortages are affecting mainly the nationalized industries; the National Coal Board, for instance, wants to achieve a net increase in its labour force of 10 per cent. by the end of the year.

DEEP DRAWS . . .



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Current Prices of Iron, Steel, and Non-ferrous Metals

(Delivered unless otherwise stated)

July 18, 1956

PIG-IRON

Foundry Iron.—No. 3 IRON, CLASS 2:—Middlesbrough, £17 11s. 0d.; Birmingham, £17 3s. 3d.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent. P, £20 8s. 0d., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si), d/d within 60 miles of Stafford, £20 12s. 3d.

Scotch Iron.—No. 3 foundry, £21 14s. 6d., d/d Grangemouth.

Cylinder and Refined Irons.—North Zone, £23 16s. 6d.; South Zone, £23 19s. 0d.

Refined Malleable.—P, 0.10 per cent. max.—North Zone, £25 4s. 0d.; South Zone, £25 6s. 6d.

Hematite.—Si up to 2 per cent., S. & P. over 0.03 to 0.05 per cent. :—N.-E. of England (local iron), £21 7s. 6d.; Scotland (Scotch iron), Zone S. 1, £21 14s. 0d.; Sheffield, £22 14s. 6d.; Birmingham, £23 2s. 0d.; Wales (Welsh iron), £21 7s. 6d.

Basic Pig-iron.—£18 3s. 0d. all districts.

FERRO-ALLOYS

(Per ton unless otherwise stated, delivered)

Ferro-silicon (6-ton lots and over).—45 per cent. Si, £48 0s. 0d. to £50 5s. 0d., scale 16s. 0d. to 17s. 6d. per unit; 75 per cent. Si, £70 0s. 0d. to £73 2s. 6d., scale 16s. 0d. to 17s. 6d. per unit.

Ferro-vanadium.—50/60 per cent., 27s. 6d. per lb. of V.

Ferro-molybdenum.—65/75 per cent., carbon-free, 11s. 6d. per lb. of Mo.

Ferro-titanium.—20/25 per cent., carbon-free, £250 0s. 0d.; 38/40 per cent., £299 0s. 0d.

Ferro-tungsten.—80/85 per cent., 17s. 8d. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 20s. 8d. per lb. of W.

Ferro-chrome (6-10 ton lots).—4/6 per cent.C, £93 10s.0d. to £95 0s. 0d., basis 60 per cent. Cr, scale 29s. 9d. to 32s. 0d. per unit; over 6 per cent. C, £92 10s. 0d. to £93 0s. 0d., basis 60 per cent. Cr, scale 29s. 9d. to 32s. 0d. per unit; 2 per cent. C,* 2s. 1d. per lb. Cr; 1 per cent. C,* 2s. 1½d. per lb. Cr; 0.15 per cent. C,* 2s. 2½d. per lb. Cr; 0.10 per cent. C,* 2s. 2¾d. per lb. Cr; 0.06 per cent. C,* 2s. 3d. per lb. Cr.

Metallic Chromium.—98/99 per cent., 7s. 0d. to 7s. 6d. per lb.

Metallic Manganese.—93/95 per cent., carbon-free, £249 0s. 0d.; 96/98 per cent., £259 0s. 0d. to £265 0s. 0d.

Ferro-columbium.—65/75 per cent., Nb + Ta, 22s. 6d. to 23s. 6d. per lb., Nb + Ta.

Ferro-manganese (home).—78 per cent., £66 0s. 0d.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—BASIC: Soft, u.t., £28 19s. 0d.; tested, 0.08 to 0.25 per cent. C, £29 19s. 0d.; hard (0.41 to 0.60 per cent. C), £31 0s. 6d.; silico-manganese, £39 10s. 0d.; free-cutting, £33 3s. 0d. SIEMENS MARTIN ACID: Up to 0.25 per cent. C, £36 14s. 6d., silico-manganese, £39 17s. 6d.

Billets, Blooms, and Slabs for Forging and Stamping.—Basic, soft, up to 0.25 per cent. C, £34 13s. 6d.; basic, hard, over 0.41 up to 0.60 per cent., C, £35 16s. 0d.; acid, up to 0.25 per cent. C, £38 17s. 6d.

FINISHED STEEL

Heavy Plates and Sections.—Ship plates (N.-E. Coast), £35 7s. 0d.; boiler plates (N.-E. Coast), £37 17s. 0d.; floor plates (N.-E. Coast), £36 16s. 0d.; sectional material, N.-E. Coast, £33 16s. 6d.

Small Bars, Sheets, etc.—Rounds and squares, under 3 in., untested (4-ton lots), £36 3s. 0d.; flats, 5 in. wide and under (4-ton lots), £36 3s. 0d.; hoop and strip, £36 12s. 6d.; uncoated strip mill coils, hot rolled, under 3mm. to 12g., £38 16s. 0d.; black sheets (hand mill), 17/20 g., £50 4s. 6d.; galvanized corrugated sheets, 24 g., £62 7s. 0d.

Alloy Steel Bars.—1 in. dia. and up: Nickel, £61 13s. 9d.; nickel-chrome, £85 10s. 6d.; nickel-chrome-molybdenum, £96 16s. 6d.

NON-FERROUS METALS

Copper.—Cash, £278 10s. 0d. to £279 0s. 0d.; three months, £277 0s. 0d. to £277 10s. 0d.; settlement, £279 0s. 0d.

Copper Tubes, etc.—Solid-drawn tubes, 2s. 10½d. per lb.; rods, 326s. 0d. per cwt. basis; 20 s.w.g., 359s. 3d. per cwt.

Tin.—Cash, £742 0s. 0d. to £745 0s. 0d.; three months, £742 0s. 0d. to £743 0s. 0d.; settlement, £745 0s. 0d.

Lead (Refined Pig).—First half July, £113 5s. 0d to £113 10s. 0d.; first half October, £111 15s. 0d. to £112 0s. 0d.

Zinc.—First half July, £93 5s. 0d. to £93 10s. 0d. first half October, £92 10s. 0d. to £92 15s. 0d.

Zinc Sheets, etc.—Sheets, 15 g. and thicker, all English destinations, £125 5s. 0d.; rolled zinc (boiler plates), all English destinations, £123 0s. 0d.; zinc oxide (Red Seal), d/d buyers' premises, £110.

Brass Tubes, etc.—Solid-drawn tubes, 2s. 4¼d. per lb.; rods, drawn, 3s. 2¼d.; sheets to 10 w.g., 312s. 3d. per cwt.; wire, 3s. 0d.; rolled metal, 297s. 3d. per cwt.

Brass (Brazing).—BS1400, B3 (65/35), £182; B6 (85/15), —; BS249, —.

Brass (High Tensile).—BS1400, HTB1 (30 tons), — HTB2 (38 tons), —; HTB3 (48 tons), —.

Gunmetal.—BS1400, LG2 (85/5/5/5), £255; LG3 (86/7/5/2), £263; G1 (88/10/2/½), —; (88/10/2/1), £305.

Phosphor Bronze.—BS1400, PB1 (AID released), — per ton.

Phosphor Bronze Strip, etc.—Strip, 429s. 6d. per cwt.; sheets to 10 w.g., 454s. 0d. per cwt.; wire, 4s. 5½d. per lb.; rods, 3s. 9½d.; tubes, 3s. 7¾d.; chill cast bars: solids 3s. 9d., cored 3s. 10d. (CHARLES CLIFFORD, LIMITED).

Nickel Silver, etc.—Rolled metal, 3 in. to 9 in. wide × 0.056, 4s. 1d. per lb.; round wire, 10g. in coils (10 per cent.), 4s. 5¾d.; special quality turning rod, 10 per cent., ½ in. dia., in straight lengths, 4s. 4¾d. All prices are net.

Other Metals.—Magnesium, ingots, 2s. 4d. per lb. Antimony, English, 99 per cent., £210 0s. 0d. Quicksilver, ex-warehouse, £84 15s. 0d. to £85 0s. 0d. Nickel, £519 0s. 0d. Aluminium ingots, £189 0s. 0d.; aluminium bronze (BS1400), AB1, —; AB2, —. Solder, brazing, BS1945, type 8 (50/50), 3s. 1d. per lb., type 9 (54/46), 3s. 4½d. per lb.

* Average 68–70 per cent.